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International Infantry & Joint Services
Small Arms Systems Section Symposium, Exhibition & Firing Demonstration

13-16 May 2002

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Division SNC Technologies Inc.

SIMUNITION®

NDIA Small Arms Symposium

15 May 2002

TRAINING FOR THE REAL WORLD™

SIMUNITION® Reduced Energy Cartridges

Presented by: ***John MacDougall,***
SIMUNITION® Product Manager

SNC TEC

SIMUNITION® Reduced Energy Cartridges

National Defense Industrial Association & TACOM-ARDEC
2002 International Infantry & Joint Services
Small Arms Symposium

E-mail contact: macdouJ@snctec.com

SNC TEC Profile

- **SIMUNITION® is a business unit of SNC TEC, dedicated to Non-Toxic Training ammunition**

- **SNC TEC is Canada's primary ammunition manufacturer:**
  - Making defence products for over 100 years
  - Revenues forecast in 2002: $ 275 million
  - Employees in 2002: 1,200
  - Registered ISO 9001 - 2000 version
  - Canadian Centre of Excellence for Ammunition Technology

SNC TEC

TRAINING FOR THE REAL WORLD™

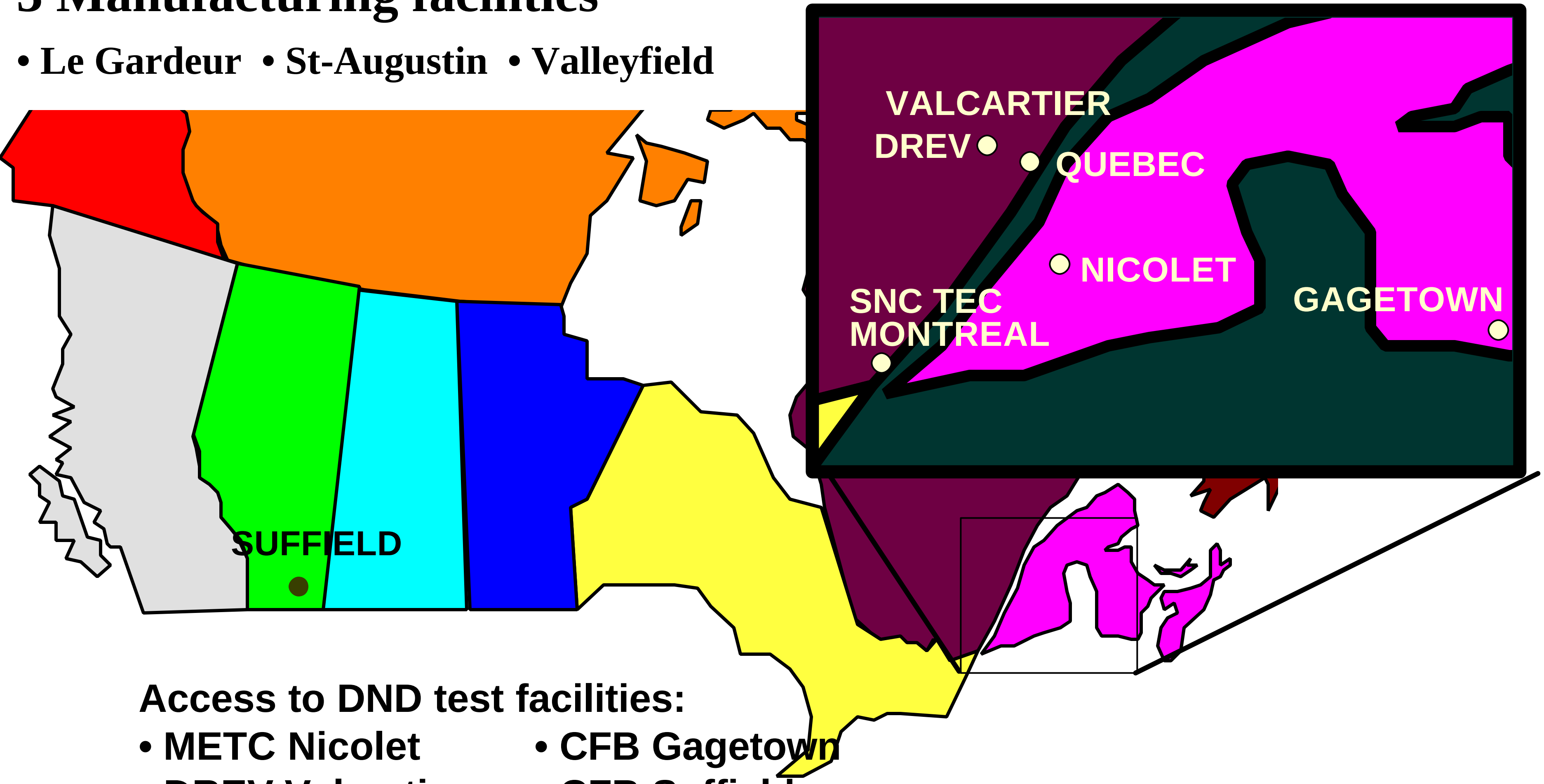
SNC TEC Facilities

- **SNC TEC has 3 manufacturing and several test facilities:**
  - LAP operations, primers at Le Gardeur, near Montréal, QC
  - Brass cases & inert components at St-Augustin, near Québec
  - Propellant manufacturing plant EXPRO TEC at Valleyfield, QC
  - Canadian DND Proof range operated as a GOCO at Nicolet, QC
  - US Headquarters at Avon, CT
  - Sales offices in Brussels, Asia and the Mid-East
- **SNC TEC is accredited as the NATO test center in Canada**

SNC TEC Plants and Test Sites

3 Manufacturing facilities

• Le Gardeur • St-Augustin • Valleyfield



Access to DND test facilities:

- **METC Nicolet**
- **DREV Valcartier**
- **CFB Gagetown**
- **CFB Suffield**

SNC TEC

SNC TEC US Headquarters

- **SNC TEC Corp. in Avon, Connecticut**
- **Opened in 1996**
  - Co-Located with SIMUNITION® USA office
  - Contact for SIMUNITION® DOD inquiries:
  - Mr. Ruben Regalado, US Business Manager
    - E-mail: regalar@pcnet.com
    - Telephone: 860-404-0162

Division SNC Technologies Inc.

SIMUNITION

TRAINING FOR THE REAL WORLD™

SIMUNITION® Reduced Energy Cartridges

TRAINING FOR THE REAL WORLD™

SIMUNITION® Reduced Energy Cartridges

- In 1990 SIMUNITION® developed a new caliber of training ammunition:
  - The “9mm FX® Marking Cartridge”
    - FX® is a telescoping cartridge with sabot & sub-caliber projectile
    - Projectile filled with inert, water-soluble marking compound
    - Reduced energy for realistic, non-lethal interactive training

FX® Marking Cartridges

➢ FX® Background:

- FX® sold to Law Enforcement & Special Forces for many years
- More than 100 Million FX® sold to date
- In service in over 40 countries around the world
- SIMUNITION® holds numerous patents for these products
- FX® currently available in 9mm and .38 cal

FX® Marking Cartridges

➢ FX® Features & Benefits:

- Excellent tool for MOUT mission rehearsal
- Realistic interactive scenarios possible without causing harm
- Reduce high-risk behavior through impact penalty
- Accurate assessment of lethality through clear hit placement
- Safer & cleaner than using Blanks with BFA
- SIMUNITION® converted weapons cannot fire lethal ammo
- Training with the user's actual weapon w/o adding weight
- Compatible with LASER-activated battle simulators (MILES)

FX® Marking Cartridges

- **FX® Marking Cartridges:**

FX® MARKING CARTRIDGES

•9mm & .38 cal

TRAINING FOR THE REAL WORLD™

SIMUNITION® Reduced Energy Cartridges

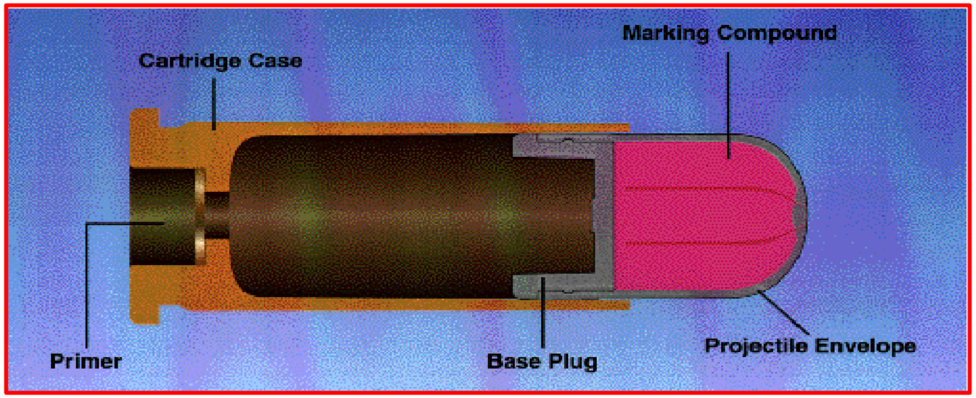
➢ SIMUNITION® Philosophy for FX® Marking Cartridges:

- 1. Produce <u>safe</u>, realistic Interactive Ammunition
- 2. Design <u>safe</u>, reliable Weapon Conversions
- 3. Provide <u>safe</u>, qualified Protective Equipment
- 4. Offer <u>safe</u>, effective Training Courses

FX® Marking Cartridges

- **SIMUNITION® .38 cal FX®:**

FX® for Revolvers

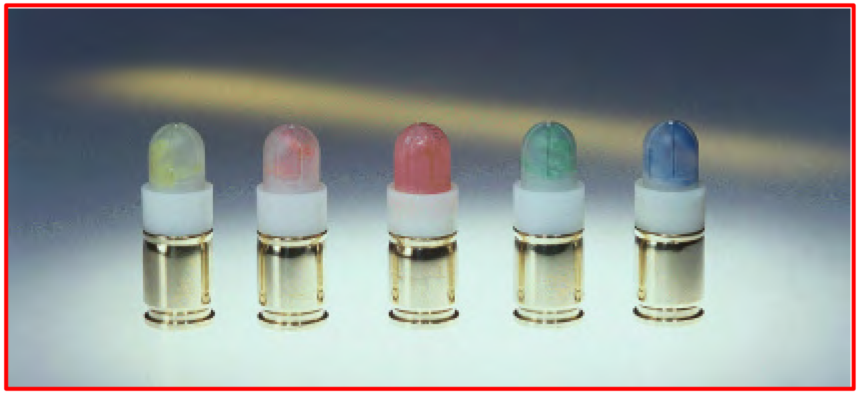


FX® for Shotguns - Less Lethal Scenario training:

Ballistic match to tactical distances

SIMUNITION® Reduced Energy Cartridges

➢ SIMUNITION® 9mm FX® for Assault Rifles/Carbines:



5 colors of 9mm FX® now available

Yellow, Orange, Red, Green and Blue

Complete Upper Receiver FX® conversions for M16/M4 family.

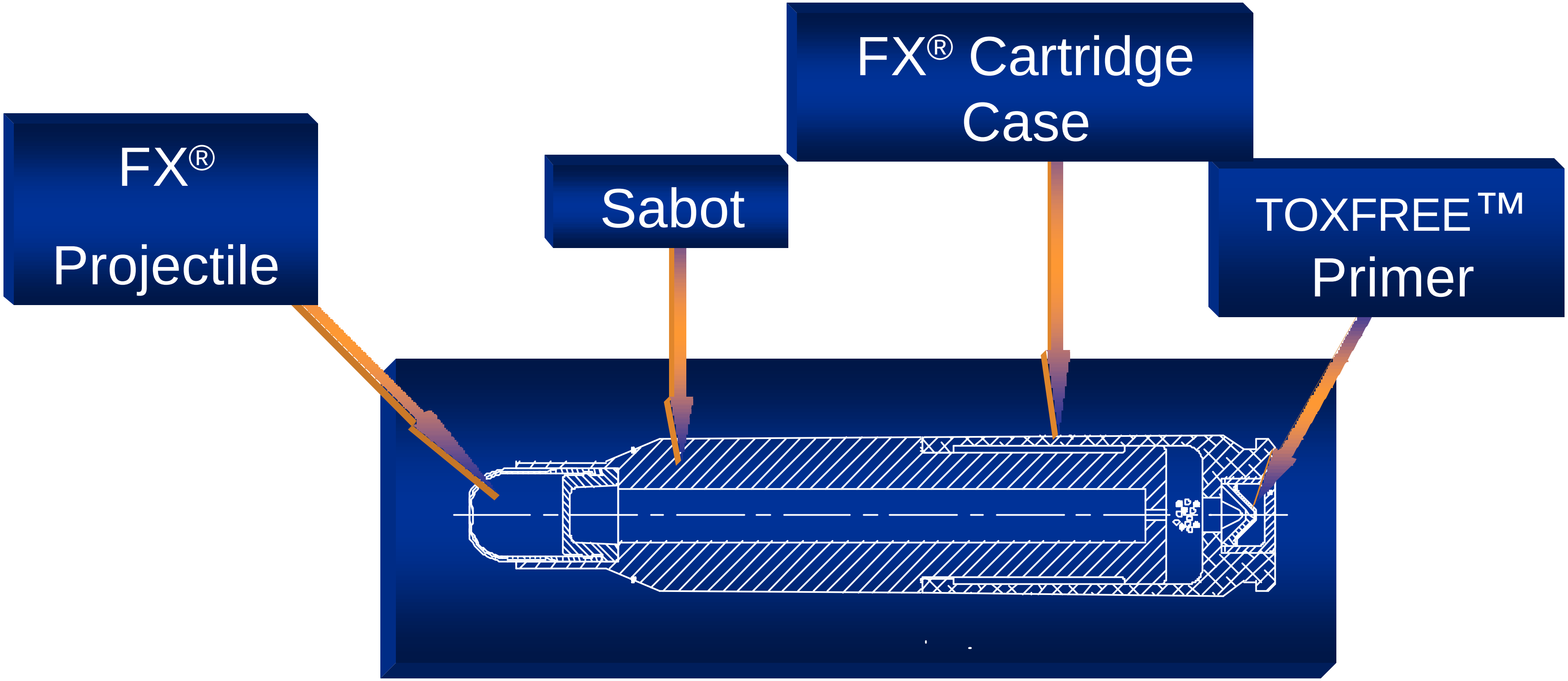
Safe FX® Clear plastic magazine provided.

New SIMUNITION® Reduced Energy Cartridge

- **SIMUNITION® Design Objectives for a new caliber: 5.56mm**
  - Develop FX® for the M4/M16, M249 and other assault rifles
  - Design safe drop-in bolt conversion
  - Complete industrialization of a 10-year old concept
  - Complimentary to 9mm FX® for M4/M16 upper receiver kit
  - Introduce the new TOXFREE™ (non-toxic) small rifle primer

TRAINING FOR THE REAL WORLD™

New 5.56mm FX® Marking Cartridge



5.56mm FX® Marking Cartridge Components

5.56mm Marking Cartridge

- **SIMUNITION® 5.56mm FX®**
- **Projectile**
  - Plastic shell containing washable color marking compound
- **Cartridge Case**
  - IVI Brass with modified FX® geometry for safety
- **Primer**
  - TOXFREE™ (lead & heavy-metal free) small rifle primer
- **Propellant**
  - Double base smokeless propellant

TRAINING FOR THE REAL WORLD™

5.56mm FX® Perfomance Specifications

- **5.56mm FX® Ballistic Performance**
- **Accuracy at 10m**
  - 15cm max Extreme Spread
- **Accuracy at 30m**
  - Impact Silhouette targets without adjusting sights
- **Ballistic match at 30m**
  - MPI within ± 30 cm of NATO ball round

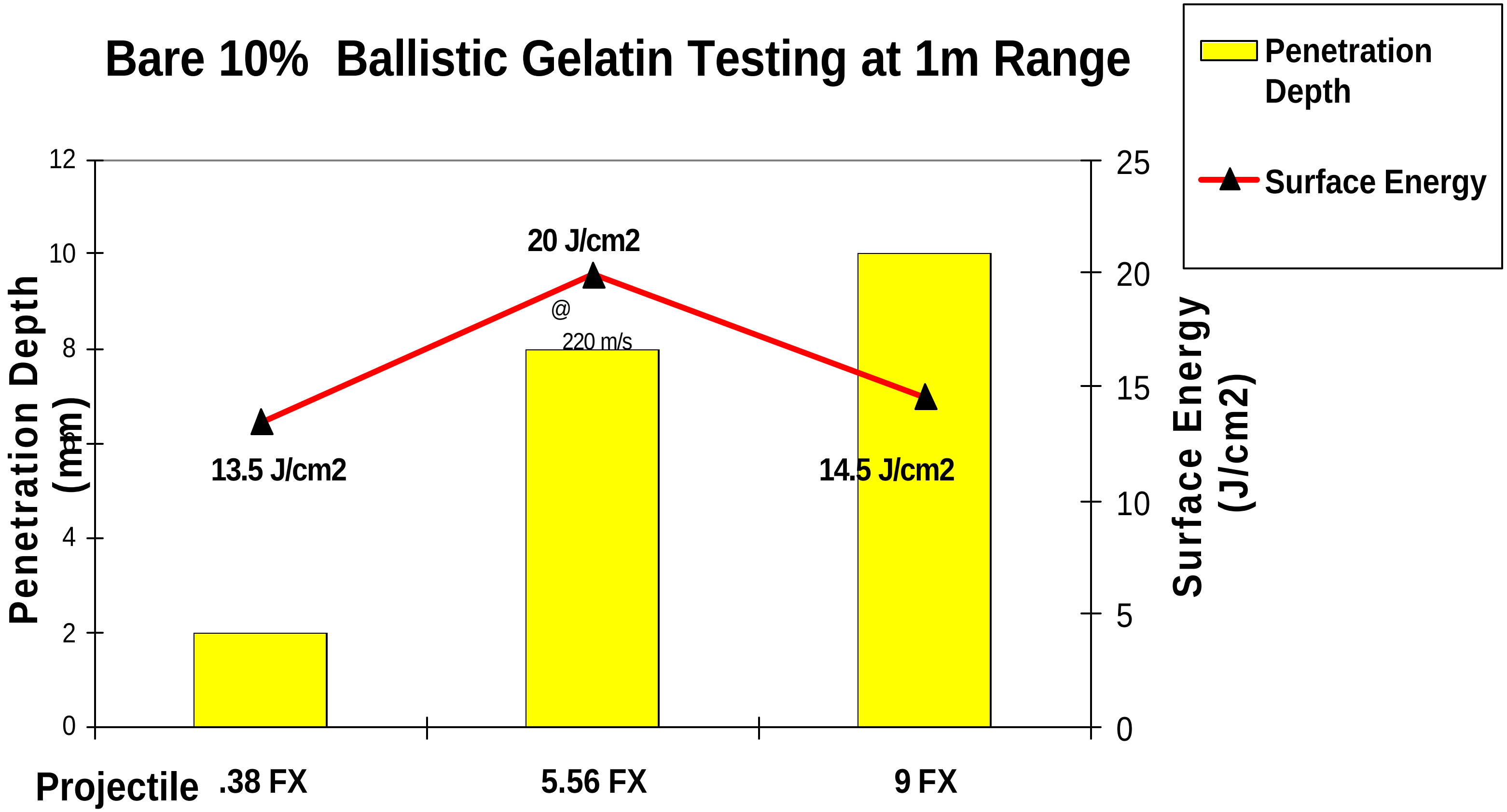
5.56mm FX® Performance Specifications

- **EPVAT at +21° C**
- **Muzzle Velocity**
  - 200 ± 20 m/s (depending on weapon)
- **Chamber Pressure**
  - ≤ 20 MPa (~3,000 PSI)
- **Functioning**
  - – Normal function in full automatic, burst or single shot modes

5.56mm FX® Terminal Effects

- **Similar Terminal Ballistics to 9mm FX®**
- **No penetration of 20% bare gelatin**
  - Impossible to measure terminal effects in 20% gelatin
- **Comparison testing in 5% and 10% gelatin**
  - No penetration of gelatin protected by a single layer of clothing
  - Bare gelatin required to obtain measurements
  - 5% gelatin too soft to differentiate penetration depth
  - 9mm FX® had deeper penetration than 5.56mm FX® in 10%

5.56mm FX® Terminal Effects



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SIMUNITION

TRAINING FOR THE REAL WORLD™

5.56mm FX® Terminal Effects

➢ Comparison of Muzzle Velocity & Energy

– 3 different calibers of FX® Marking Cartridges:

	Velocity m/s	Muzzle Energy Joules	Surface Energy J/cm
.38 mm FX®	160	8.5	13.5
9 mm FX®	165	6.5	14.5
5.56 mm FX®	220	5.0	20.0

- .38 cal FX® has the largest muzzle kinetic energy
- 9mm FX® has the deepest penetration in 10% gelatin
- 5.56mm FX® has the highest surface energy level

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TRAINING FOR THE REAL WORLD™

5.56mm FX® Terminal Effects

➢ Comparison of Impact Penalty

- Performed on SIMUNITION® "volunteers"
- 9mm FX® vs 5.56mm FX®
- Tested at 5m range
- Subjects protected by BDU-type clothing
- Similar impact penalty in 5.56mm and 9mm FX®
- Impossible to distinguish between calibers

5.56mm FX® Marking on Flak Jacket

TRAINING FOR THE REAL WORLD™

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SIMUNITION

5.56mm FX® Marking on Lexan target

5.56mm FX® Bolt Conversions

- **Conversion bolts for 5.56mm weapons:**
  - M4 carbines, M16 rifles, M249 SAW & FN MIMIMI
  - Conversion bolt and SIMUNITION® BLUE™ feed tray:
    - Converts weapon to straight blow-back
    - Visibly distinguishable from service bolt
    - Live fire exclusion features built into bolts for safety to users

TRAINING FOR THE REAL WORLD™

5.56mm FX® bolt for M4/M16

User Installed & maintained, no tools required, bolt change only

FX® Conversion kit for M249 Machine gun

SIMUNITION® BLUE™ feed tray
& conversion bolt - with safety features built-in

5.56mm FX® Marking Cartridges

- **Available in 5 Colors:**
  - Florescent Red, Blue, Green, Orange, Yellow
  - Sealed projectile ensures bullet integrity in bore
  - Projectile design ensures excellent marking on target
  - Linked or clipped

TRAINING FOR THE REAL WORLD™

Division SNC Technologies Inc.

SIMUNITION

5.56mm FX® Marking Cartridges

- **Linked for machine guns :M249, MINIMI**

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SIMUNITION

TRAINING FOR THE REAL WORLD™

SIMUNITION® Marking Cartridges

- **The complete family:**
  - 9mm FX®
  - .38 cal FX®
  - 5.56mm FX®

TRAINING FOR THE REAL WORLD™

Division SNC Technologies Inc.

SIMUNITION

SIMUNITION® 5.56mm FX® Marking Cartridges

- **SUMMARY**
  - **The new 5.56mm FX®:**
    - Is a new caliber for SIMUNITION®
    - Functions the M4/M16 and M249
      - Only drop-in safe bolt conversion required
    - Is completely non-toxic and non-lethal
    - Is an addition to the 9mm FX® for M4/M16 & M9, M11 kits
    - Design leverages past performance of 9mm FX®
  - **The Solution for**: CLOSE COMBAT MISSION CAPABILITY KIT

Simulating 21st Century Dismounted Combatant Operations

Presented by

Dale Malabarba

Modeling and Analysis Team Leader

Natick Soldier Center

15 May 2002

Outline

- ✓ Background
  - Where we've been
  - Where we need to go
- ✓ A vision for Modeling & Analysis
- ✓ Facts of life
- ✓ It's about analysis, not modeling
- ✓ The challenges
  - What's required, and what constitutes success?
- ✓ Where we are
- ✓ Gazing into the crystal ball
- ✓ The way forward
- ✓ Summary

Where We've Been

- ✓ During the Vietnam Era, an individual combatant was a "Christmas Tree" on which items were hung
- ✓ Models and analyses were focused on a stove-piped "Eaches" approach, with separate and independent models for
  - Ballistic effects
  - Chemical effects
  - High level, force-on-force battles

Where We Need To Go

Paradigm Shift

… Christmas Tree

… Integrated Human-Centric System

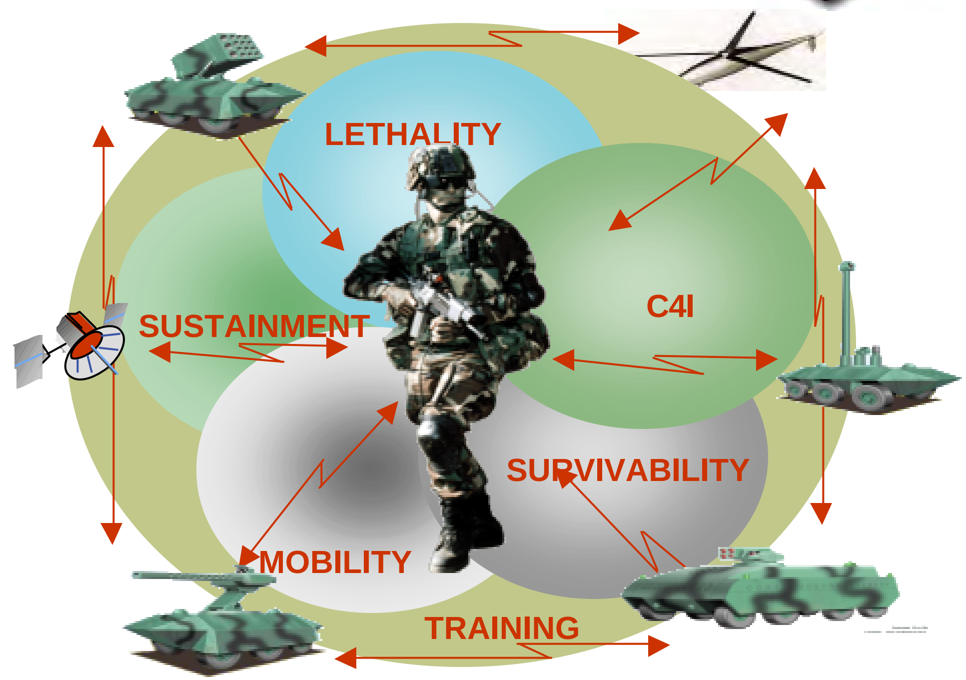
Modeling & Analysis

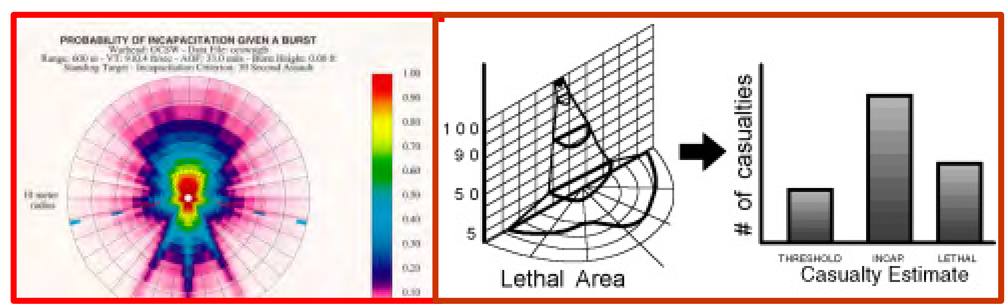
A Vision

Provide the decision maker with what he needs, when he needs it by developing and exercising the models and tools *to perform the required critical analyses* throughout the acquisition life cycle.

Facts of Life

- ✓ We cannot afford to test everything
- ✓ The best method to assess combat effectiveness requires a hierarchy of models combined and supplemented with live data using real people
- ✓ System effectiveness across all anticipated missions can be assessed only through simulation





More Facts Of Life

"When you can measure what you are speaking about, when you can express it in numbers, you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meager and unsatisfactory kind . . . scarcely advanced to the stage of science."

William Thomsen, Lord Kelvin, 1804-1907

"If I had time … to study, I think I should concentrate almost entirely on the "actualities of war", the effect of tiredness, hunger, fear, lack of sleep, weather … It is the actualities that make war so complicated and so difficult, and are usually neglected by historians."

Field Marshall Archibald Wavell, 1883-1950

Author of 'Soldiers and Soldiering'

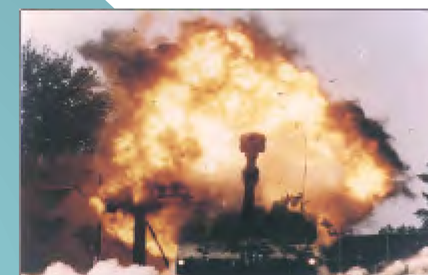
And Still More

Almost Everything But War Is Simulation

Virtual
(Apparently Real)

Training &
Educational
Community

Testing &
Evaluation
Community



Subsistent
(Real, Live)

Constructive
(Combat Model)

Operational
Community

Research,
Development &
Acquisition
Community

Operations Analysis, Not Modeling, Is The Key

So, what exactly is the problem?

Operations analyses, supported by modeling and simulation (exercises, training, operations, planning) provide the only peacetime capability to develop requirements, explore doctrine, and assess warrior systems' performance -- examining the full range of battlefield operations and hazards.

Across The Domains…

Models Must Be Complementary

- ✓ <u>Advanced Concepts and Requirements (ACR):</u> Includes combat development, doctrine development, experimentation, and requirements generation.

- ✓ <u>Research, Development, and Acquisition (RDA):</u> This domain includes: test and evaluation, training development, materiel development, and research and development technology base.

- ✓ <u>Training, Exercises, and Military Operations (TEMO):</u> Includes most forms of training at all echelons from individual trainers through collective, combined arms, combined and joint exercises. Includes rehearsals for plans and operations and evaluations of completed missions.

Guiding Principles

Customers' decision-making requirements must drive all planned efforts

CUSTOMERS' NEEDS

REQUIRED ANALYSES

Responsive to Customer Needs

METHODOLOGY INFRASTRUCTURE: TOOLS AND DATA

Critical core capability

Simulation Based Acquisition Challenges

-VS- Reality

Customer's Taste **Analyst's Budget**

- ✓ Recognize that the complete M&S solution will not be accomplished
- ✓ Prioritize and work critical parts to provide answers
- ✓ Maintain validated data repository for future upgrades/soldier systems

What's Required

Inputs

- THREAT
- MOPs
- COMPONENT/ SYSTEM SPECS
- MISSION PROFILES

ANALYSES

- FRONT END
- MISSION PERFORMANCE
- COST/BENEFIT
- RISK
- BASIS OF ISSUE
- REQUIREMENTS
- NEW CONCEPTS
- TECHNOLOGY

Outputs

COMBAT WORTH

ITEM
SYSTEM } MOEs

MOOs

SUPPORT

T&E ADVICE
VV & A
FOCUSED SCENARIOS
REQUIREMENTS VALIDATION
DATA COLLECTION

PRODUCTS

TECH DOWNSELECT
TECH TRADES
INV STRATEGY
RISK ASSEMT

How Do We Define Success?

✓Measure Of Outcome (MOO)

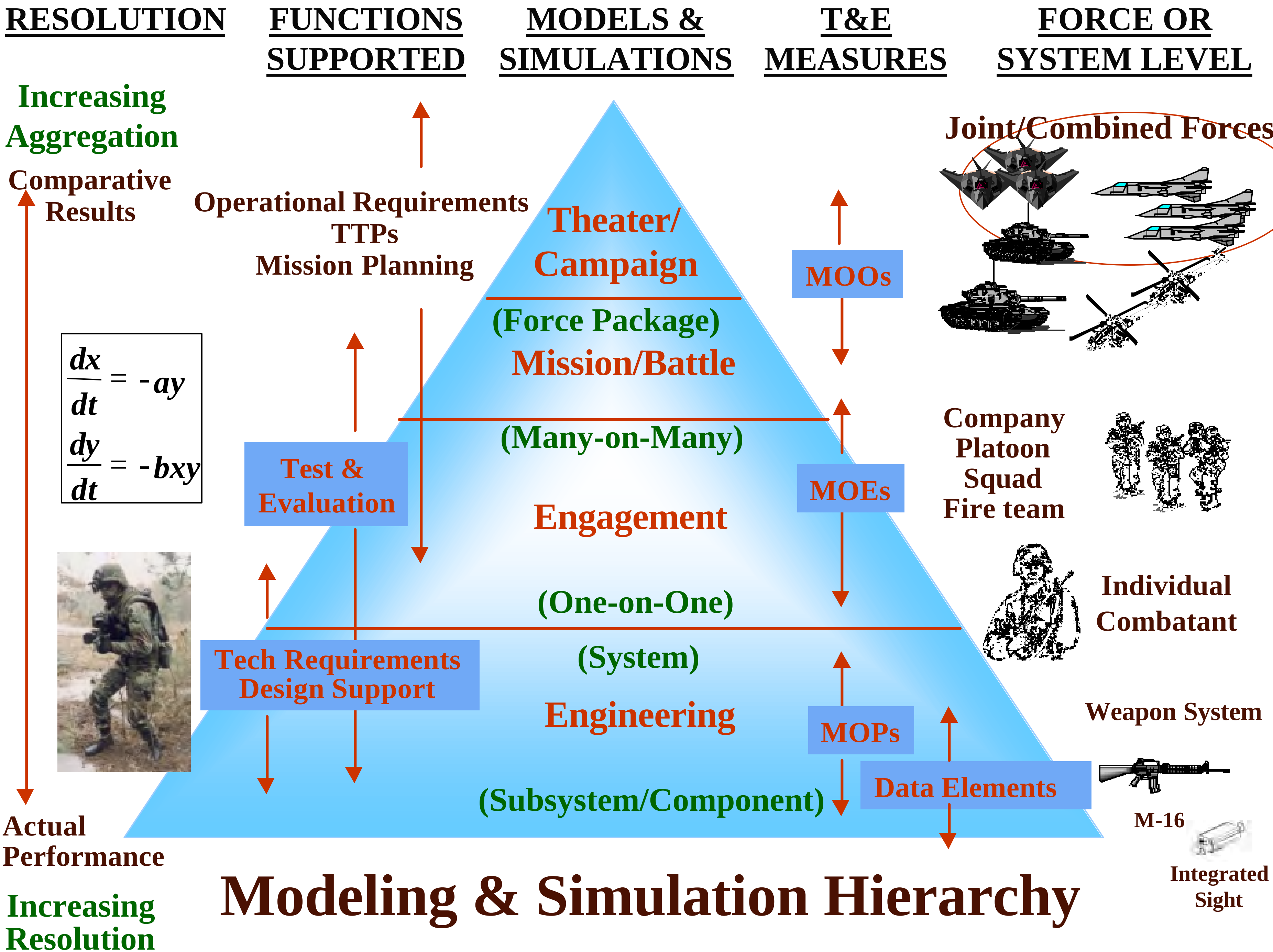
- Define How Operational Requirements Contribute To End Results At Higher Levels
- A Binary Measure, Was the Mission A Success - Yes Or No
- Modeling Should Correctly Predict Mission Outcome

✓Measure Of Effectiveness (MOE)

- Compares Effectiveness Of Alternatives In Meeting An Operational Objective Or Need (DA PAM 5-11)

✓Measure Of Performance (MOP)

- Defined Metric Of A Component Which Contributes To Basic System Effectiveness As Described By An MOE (DA PAM 5-11)
- Quantifiable Measures Of How Well Mission Tasks Are Accomplished
- Examples Include Detection Range, Number Of Rounds Expended


RESOLUTION
FUNCTIONS SUPPORTED
MODELS & SIMULATIONS
T&E MEASURES
FORCE OR SYSTEM LEVEL
Increasing Aggregation
Comparative Results
Operational Requirements
TTPs
Mission Planning
Theater/ Campaign
MOOs
Joint/Combined Forces
(Force Package)
Mission/Battle
$\frac{dx}{dt} = -ay$
$\frac{dy}{dt} = -bxy$
(Many-on-Many)
Company
Platoon
Squad
Fire team
Test & Evaluation
MOEs
Engagement
(One-on-One)
Individual Combatant
Tech Requirements
Design Support
(System)
Engineering
MOPs
Weapon System
Data Elements
M-16
(Subsystem/Component)
Integrated Sight
Actual Performance
Increasing Resolution
Modeling & Simulation Hierarchy

Where We Are

State of the Art for Dismounted Combatant Analysis

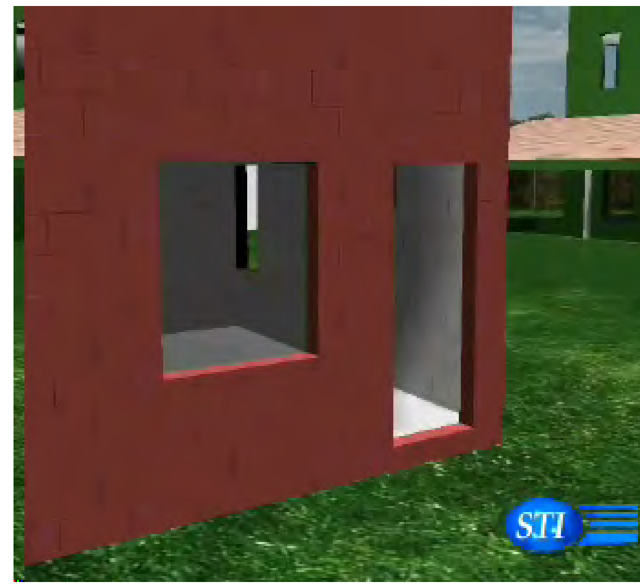
Survivability	Lethality	Mobility	Command & Control	Sustainability
Pk/Ph Vulnerability to projectiles/ fragments Thermal stress Chemical agents Simple barriers Statistical use of open field terrain cover / concealment	Pk/Ph, Pdet, Pacq Direct/Indirect fire Independent error budgets Simple suppression Pre-set or HITL target selection	Terrain/load dependent movement rates Perfect navigation Pre-set or HITL route/speed adjustments MOUT movement formations/rules	Perfect communications Perfect Situation Awareness HITL decisions based on perfect knowledge HITL decisions	Expenditure of consumable resources Limited re-supply Estimation of metabolic workload Macro-nutrient physiology and energy balance
Incremental addition of ballistic protection Non-lethal weapon effects Blunt trauma	Improved target acquisition process Integrated error budgets Stressor effects on error budgets	Terrain dependent movement Intra-building movement	Imperfect & incomplete knowledge IFF Combat ID Simple rule-based situation awareness	Limited fatigue Dynamic redistribution of unit resources
Dynamic, protection/ operability tradeoffs Dynamic terrain interaction Task dependent incapacitation Integrated Insults	Suppression as a function of situation awareness Realistic close combat in MOUT and the open field	Dynamic human response to terrain: - Route selection - Cover and concealment - Optimal use of "Position"	Situation Awareness as dynamic contingency response (pattern recognition/integrated factors)	Soldier load item utility-based optimization Integrated effects of fatigue on performance

Key: Current Capability | 1-2 Years | 2-5 Years

My Crystal Ball Indicates:

- Next-generation models must
  - better represent dismounted combatant behaviors
  - include non-combat actions, e.g. peace keeping & humanitarian roles
  - consider maneuver and attrition warfare
  - become platform independent
  - embrace modular, plug & play capabilities
- Terrain format issues must be resolved
  - SEDRIS (Synthetic Environment Data Representation & Interchange Specification) objectives must be met

Proper behavior?



The Way Forward:

Cooperation, Collaboration and Leveraging Are The Keys

The significant advances in computer simulation and software technology primarily will be driven by the:

- movie industry
- computer gaming industry
- the internet

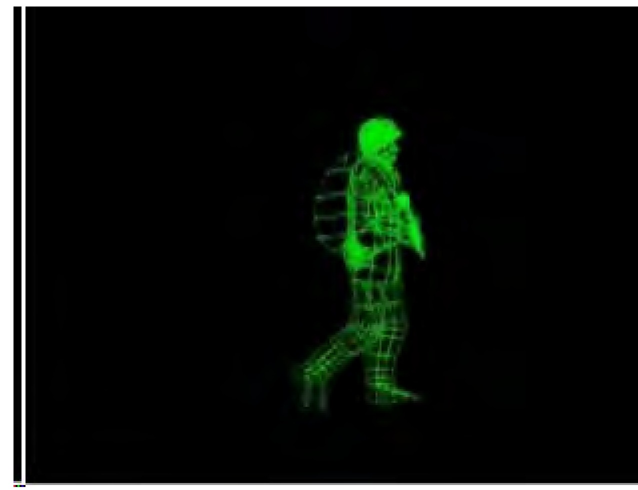
NATO & ABCA Nations Face Similar Challenges

Many of our allies also have embarked on the arduous soldier modernization journey and have adopted the soldier as a system philosophy. These include:

- ✓ Australia
- ✓ Belgium
- ✓ Canada
- ✓ France
- ✓ Germany
- ✓ Italy
- ✓ Netherlands
- ✓ New Zealand
- ✓ U.K.

To Reach Our Destination We Must:

- Team with the Combat Developer, the Technology Developers, PEO/PMs, model developers and testers across the domains.
- Develop a more seamless transition across the individual combatant M&S hierarchy.
- Cooperate, collaborate and leverage the commercial hardware & software developers/vendors.
- Apply comparative advantage with our international partners; there is no monopoly in individual combatant intellectual capital.



The Bottom Line

Modeling & Analysis Benefits To Customers

Using the principles of Simulation and Modeling for Acquisition, Requirements, and Training (SMART) and Simulation-Based Acquisition (SBA), M&A will…

✓Reduce Program **Costs**

✓Reduce Program **Schedule**

✓Reduce Program **Risk**

Summary

- ✓ Modeling and Analysis of the Individual Warrior and his unit promises significant dividends to Warrior Systems Research, Development, and Acquisition.
- ✓ We have a tremendous amount of challenging work to do.
- ✓ If we do it well, the Individual Warrior is ultimate beneficiary.
- ✓ That's about as good as it gets!

Multiple Magazine Holder

Angelo Mancini

Consultant to

Sarco, Inc., Sterling, NJ

Multiple Magazine Holder

Introduction

- Scope
- MMH Product Background
- MMH Product Improvement
- Fabrication Approach
- Test Measures & Process
- Test Results
- MMH Production

Scope

- Sarco was awarded a fixed price contract to produce 16,800 Multiple Magazine Holders (MMHs) for the Department of the Army
- MMHs were specified for use with 30 round magazines in M16 series rifles and the M4 Carbine
- Militarized version was based on an off-the-shelf non-development item (NDI)

Contract was in accordance with purchase description AR-PD-119B for Multiple Magazine Holder

MMH Product Background

- Need for MMH grew from field requirement to rapidly employ increased firepower
- Combatants typically relied on improvised methods

MMH Product Background (2)

- Field improvisations created issues
  - Magazine contamination
  - Cartridge feeding problems
  - Jammed weapons

MMH Product Background (3)

- Existing commercial off the shelf product met user requirements, however Sarco identified potential improvements for product militarization
- During preliminary in-house drop testing, the impact affected the left magazine bottom plate and spring

MMH Product Improvement

- Primary design change – the bottom of the left side MMH was extended to protect the magazine

Commercial MMH

Militarized Version

Fabrication Approach

- Complete engineering process for fabrication was established by Sarco engineering
  - Selection of desired strip materials and properties
  - Design of punch and die tooling necessary to blank and form MMH
  - Spot welding the formed part
  - Heat treating to obtain proper hardness gradient
  - Selection of an acceptable protective coating
  - Development of specified packaging

Test Measures

- First Article Inspection
  - Materials construction and design
  - Packaging inspection
  - Interfaces
  - Weight
  - Final protective finish
  - Endurance at ambient
  - Rough handling
  - Workmanship
  - Capacity
  - Magazine change time
  - Weapon vertical profile
  - Magazine and feed orientation

Testing Process

INITIAL FAB
1000 MMH;
100 submitted

TESTING & INSPECTION
28 MMH
selected

ENDURANCE TEST
2,000 rounds M855 5.66mm

ROUGH HANDLING TEST
240 rounds M855 5.66mm

Conducted at Armament Technology Facility
Picatinny Arsenal, NJ

TESTING
3 MMH
submitted

SURFACE FINISH TEST
Per MIL-STD-810

Conducted at Laboratory Testing
Dublin, PA

All testing witnessed and approved under government QAR.

Test Results

Measure	Requirement/ Notes	Test Result
Materials, Construction & Design	No formal design and construction specs.	**N/A**
Packaging Inspection	MMH is packaged in box marked with national stock number, applicable bar coding. Includes protective wrap and instruction sheet. NSN 1005-01-425-5677	**Pass**
Interface	MMH was tested with fully loaded GFM 30-round magazines as used in the M16 series rifles and M4 carbines. No special tools are required to mount and detach from the weapon.	**Pass**
Weight	MMH cannot exceed 5 ounces. Actual weight is 2.99 – 3 ounces.	**Pass**

Test Results(2)

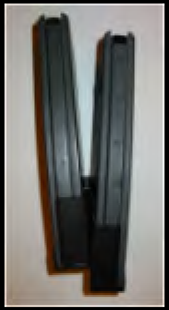
Measure	Requirement/ Notes	Test Result
Final Protective Finish	The MMH shall have - Non-reflective finish - Color (lusterless flat); approximately black - Corrosion resistance* - Preferred finish – phosphate (zinc)	 **Pass** **Pass** **Fail*** **Met**
Endurance at Ambient	Four MMHs and two M16A2 rifles were used. There was no degradation of performance in the weapons or MMHs.	**Pass**
Rough Handling	Two MMHs were assembled to two magazines fully loaded with inert ammunition, and each was dropped from an M16A2 rifle. The MMHs were then fired in accordance with test procedures.	**Pass**
Workman-ship	MMH meets the applicable workmanship standards noted in MIL-W-13855.	**Pass**

*MMH fails as result of rust (bleeding) from inside bent flange;
all surfaces in direct contract with magazine passed corrosion tests

Test Results(3)

Measure	Requirement/ Notes	Test Result
Magazine Change Time	Time to change from the first magazine to the second shall not exceed 5 seconds for both right and left-handed shooters. The average time measured during endurance tests was < 3.0 seconds.	**Pass**
Magazine Feed and Orientation	The Sarco MMH, when assembled to two magazines and attached to the M16A2, by design orients the external magazine in the same direction as the magazine loaded into the weapon.	**Pass**

Test Results(3)

Measure	Requirement/ Notes	Test Result
Weapon Vertical Profile	The vertical profile when magazines are loaded into the M16A2 must be less than 11.2 inches. The Sarco militarized MMH creates a weapon profile of 10.62 inches (left magazine loaded), and 10.00 inches (right).	**Pass** 
Capacity	MMH shall hold two thirty round magazines.	**Pass** 

MMH Production

- 16,800 militarized MMHs were produced by Sarco and delivered to the Department of the Army
- Newspaper clipping depicts deployment of MMH in the field

ASSOCIATED PRESS

A U.S. Army 82nd Airborne paratrooper holds his gun while catching a nap at the Tirana, Albania, airport. Several hundred paratroopers are assigned to protect Apache attack helicopters, which are expected to arrive soon.

Contact Information

For additional information, contact:

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Machine Gun

HK - MG43

HK - MG43

Cal. 5.56 mm x 45

102.000 ROUNDS:

1 MG43
2 Barrels
4 Gunners
6 Days

- Technical Data
- Main Design Features
- Trial (Yuma, Arizona)
- Trial (HK Oberndorf)
- Trial (Norway)
- Summary

HK - MG43

Cal. 5.56 mm x 45

Technical Data

Operation principle	Gas operated weapon with rotating bolt head
Weight	< 6.5 kg (< 14.32 lbs)

Dimensions

Total Lenght	
buttstock open	1050 mm (41 inch)
buttstock folded	810 mm (32 inch)
Width	90 mm (3.5 inch)
Total height	250 mm (9.8 inch)

HK - MG43

Cal. 5.56 mm x 45

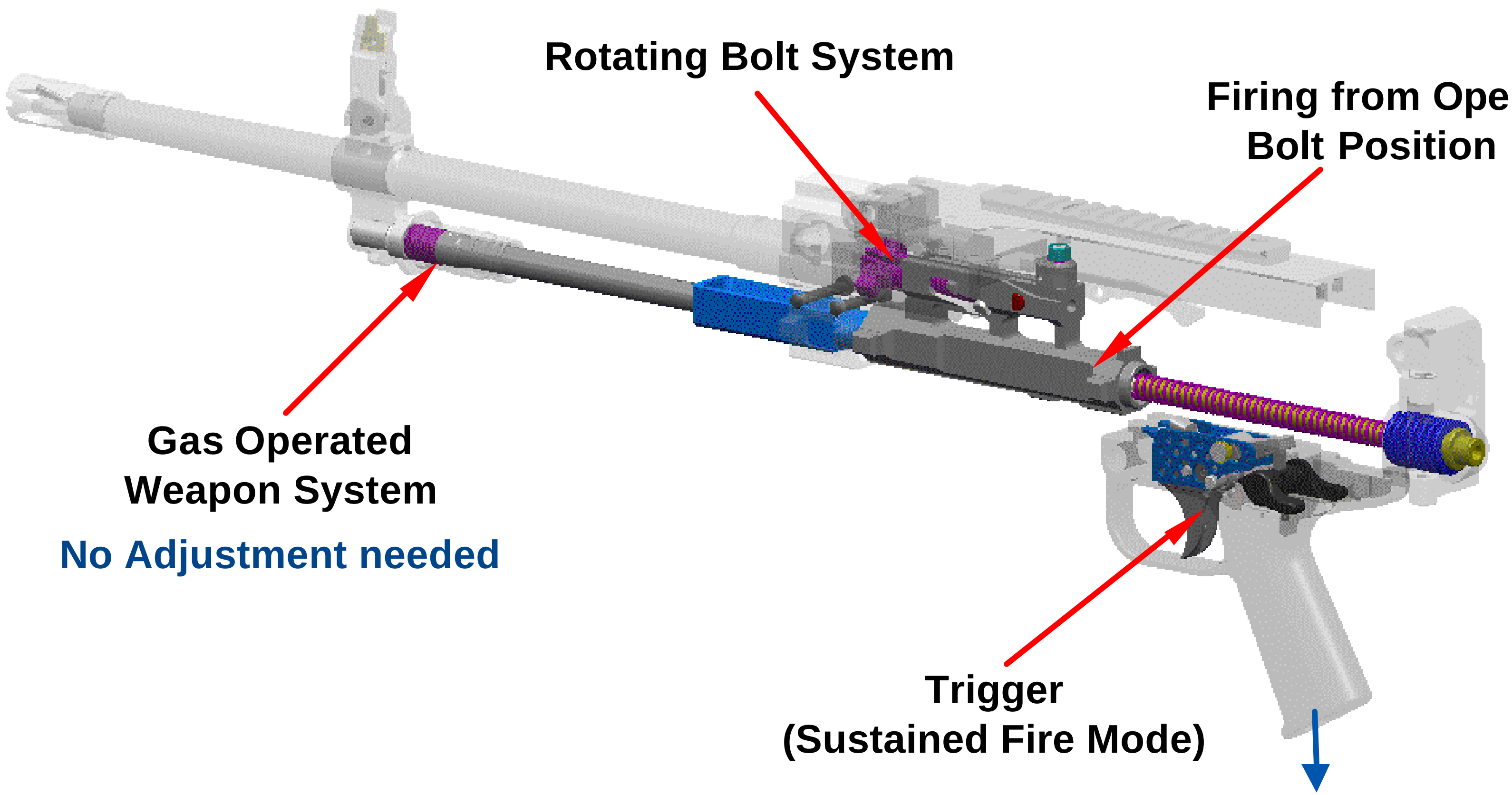
Other Data

Rate of Fire	approx. 800 rounds / min
Firing modes	full automatic
Feed	from NATO-standard linked ammunition
Transport	2 step-pawl-operated
Charging	right side folding charging handle
Ejection of spend cases	downwards / deflected to the left or right side
Barrel	quick change barrel
Carrying handle	is used for changing barrels
Bipod	integrated into handguard
Interface	for US-ground mount M2
Sight	Iron sight up to 1000 m
Sight mount	Picatinny Rail MIL Std.1913 for optical sight systems

HK - MG43

Cal. 5.56 mm x 45

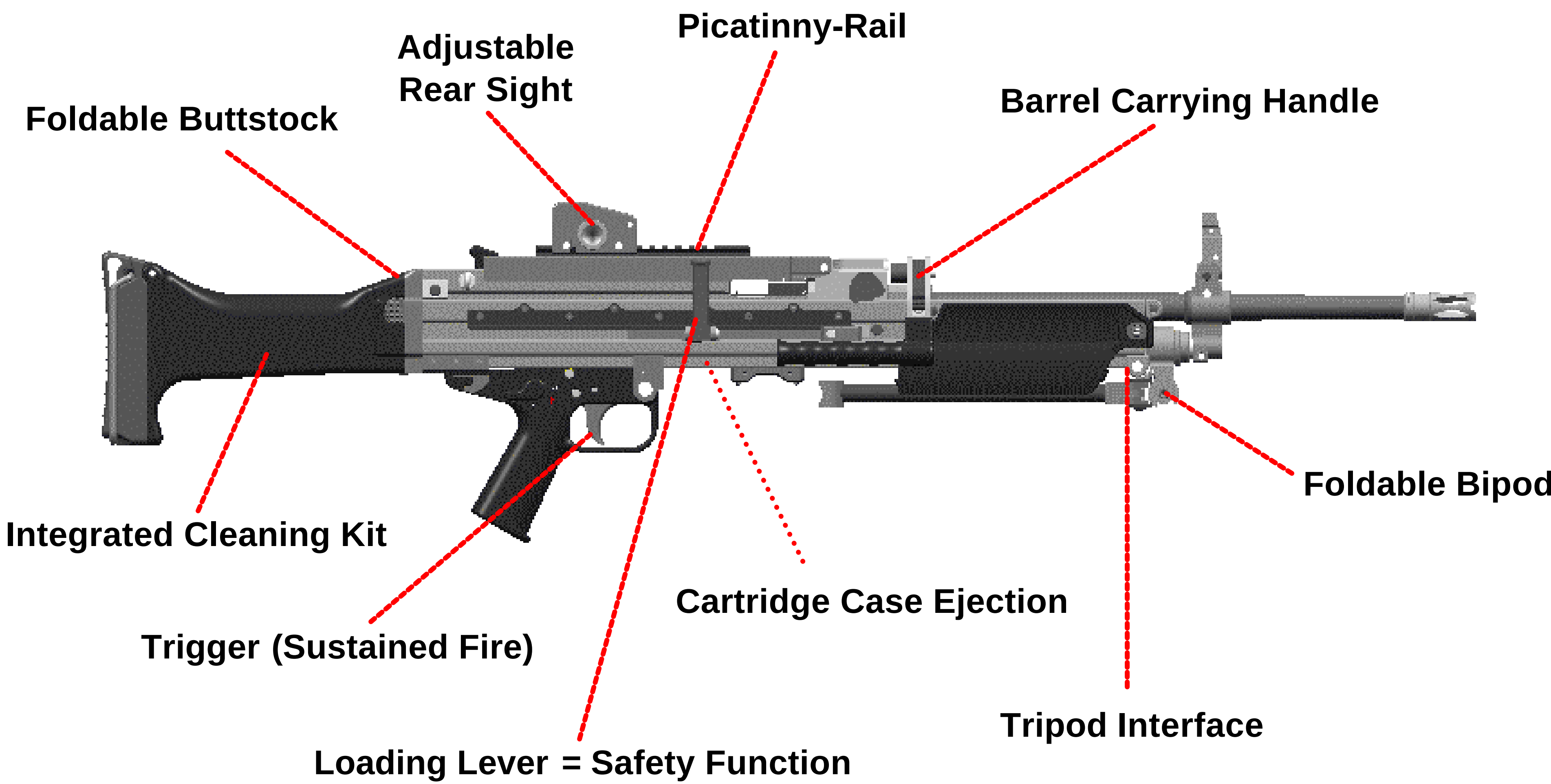
Main Features - Functional Mode



HK - MG43

Cal. 5.56 mm x 45

Main Features - Handling

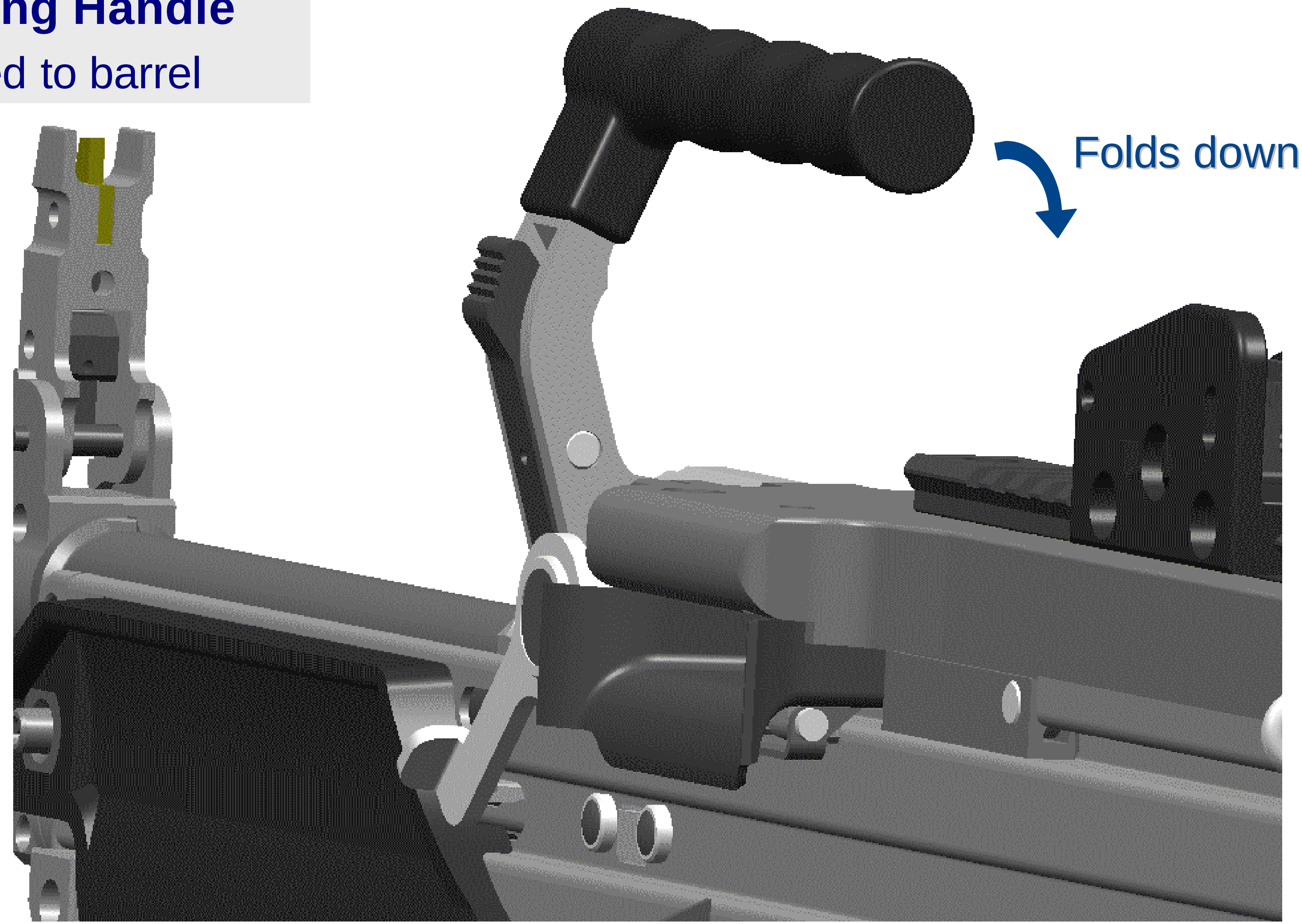


HK - MG43

Cal. 5.56 mm x 45

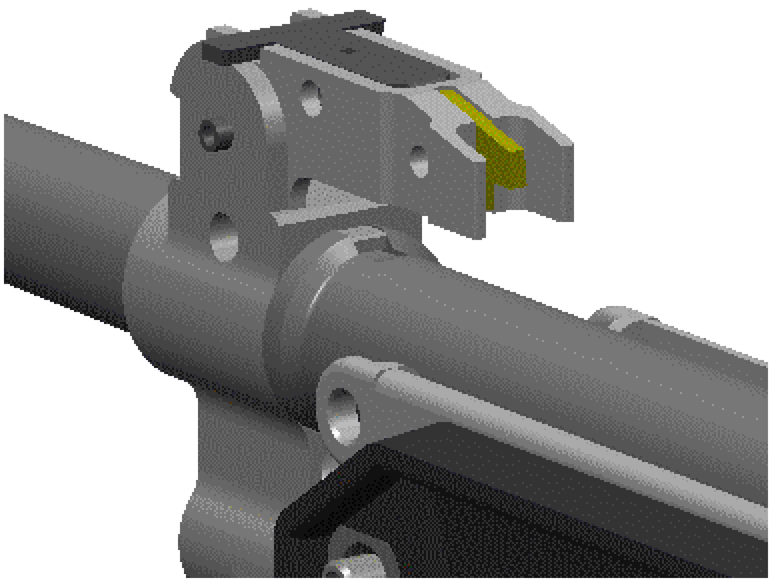
Carrying Handle

attached to barrel

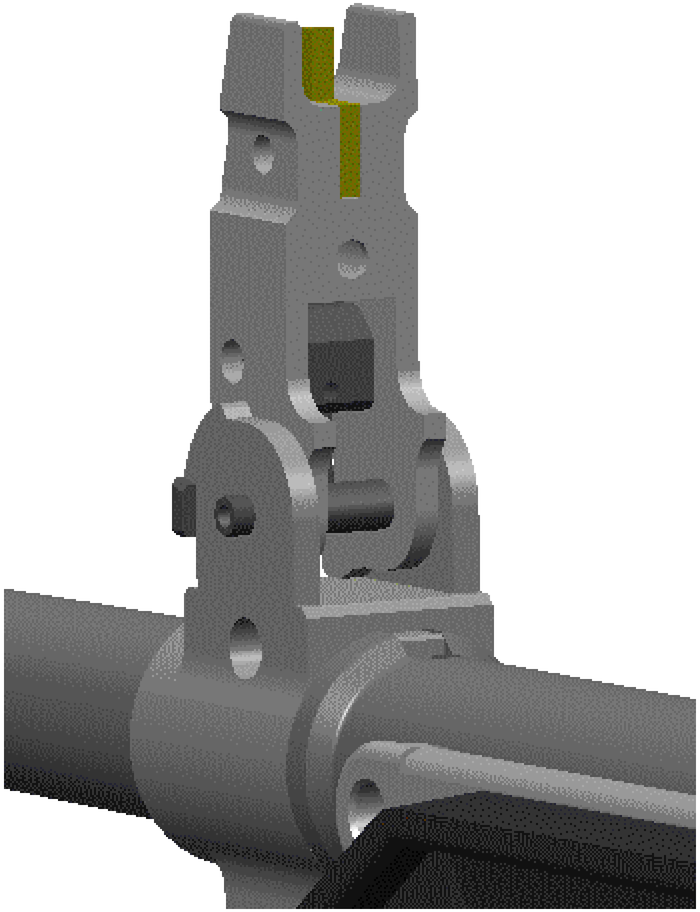


HK - MG43

Cal. 5.56 mm x 45

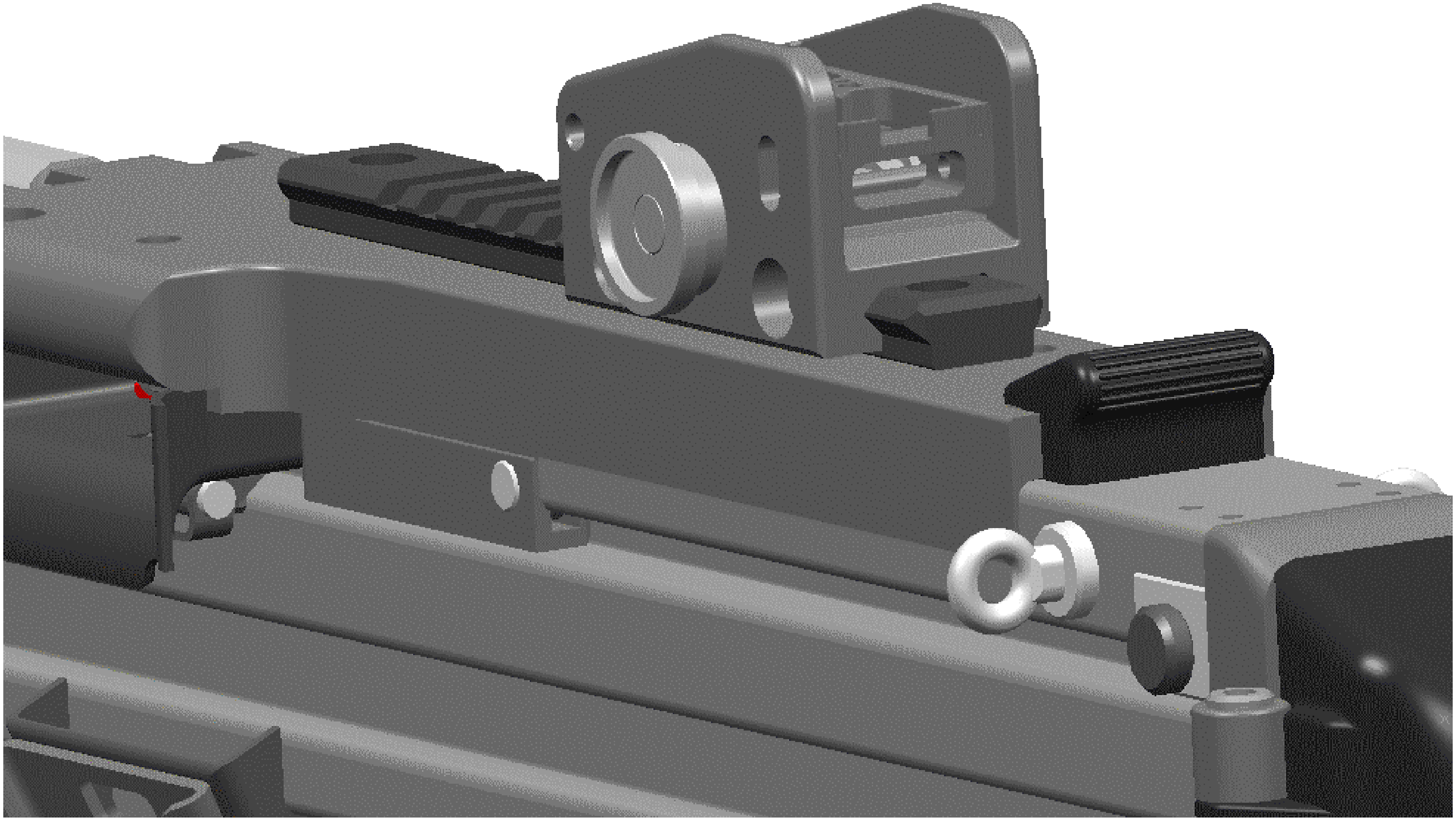


Front Sight, folded



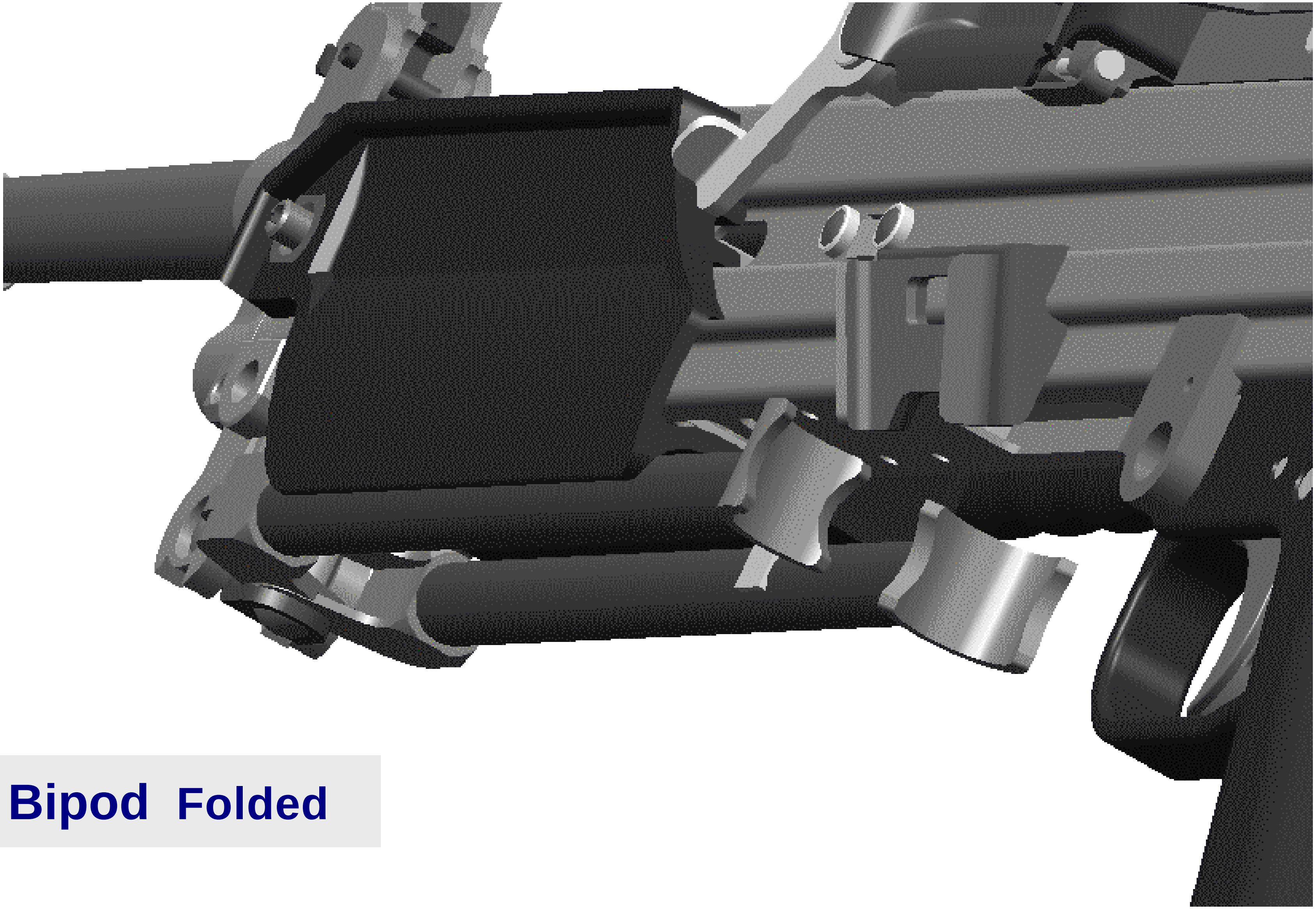
Front Sight, open

Adjustable Rear Sight



HK - MG43

Cal. 5.56 mm x 45

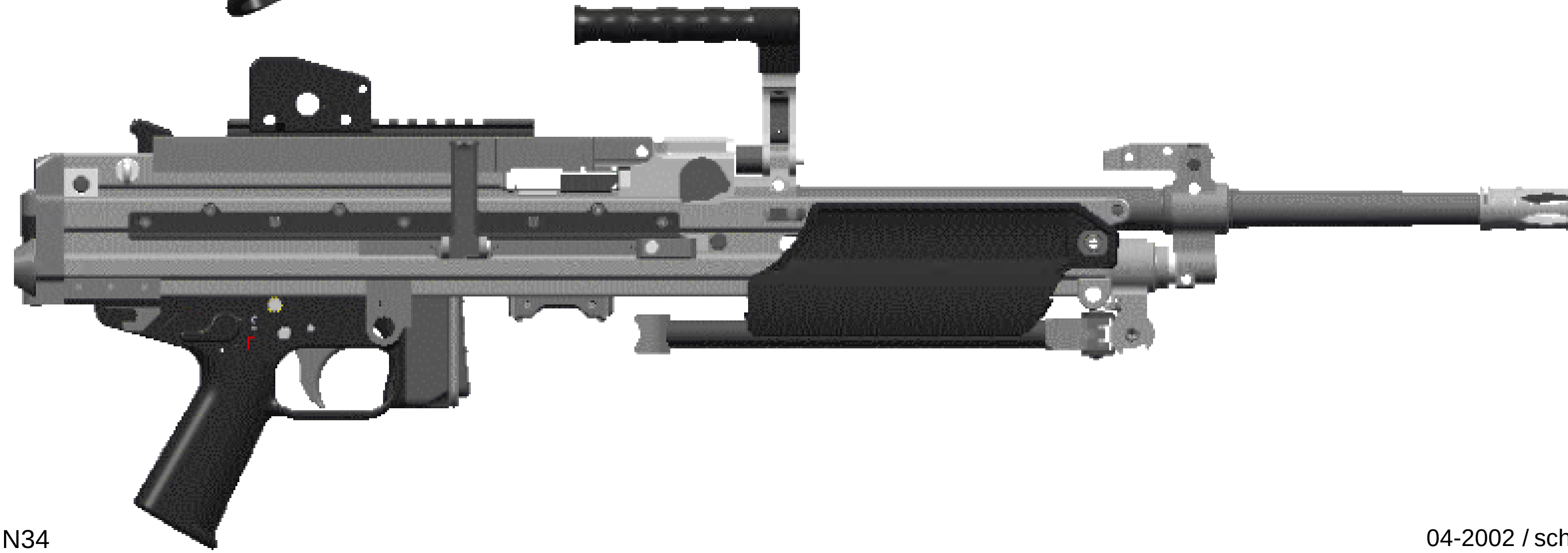


Bipod Folded

HK - MG43

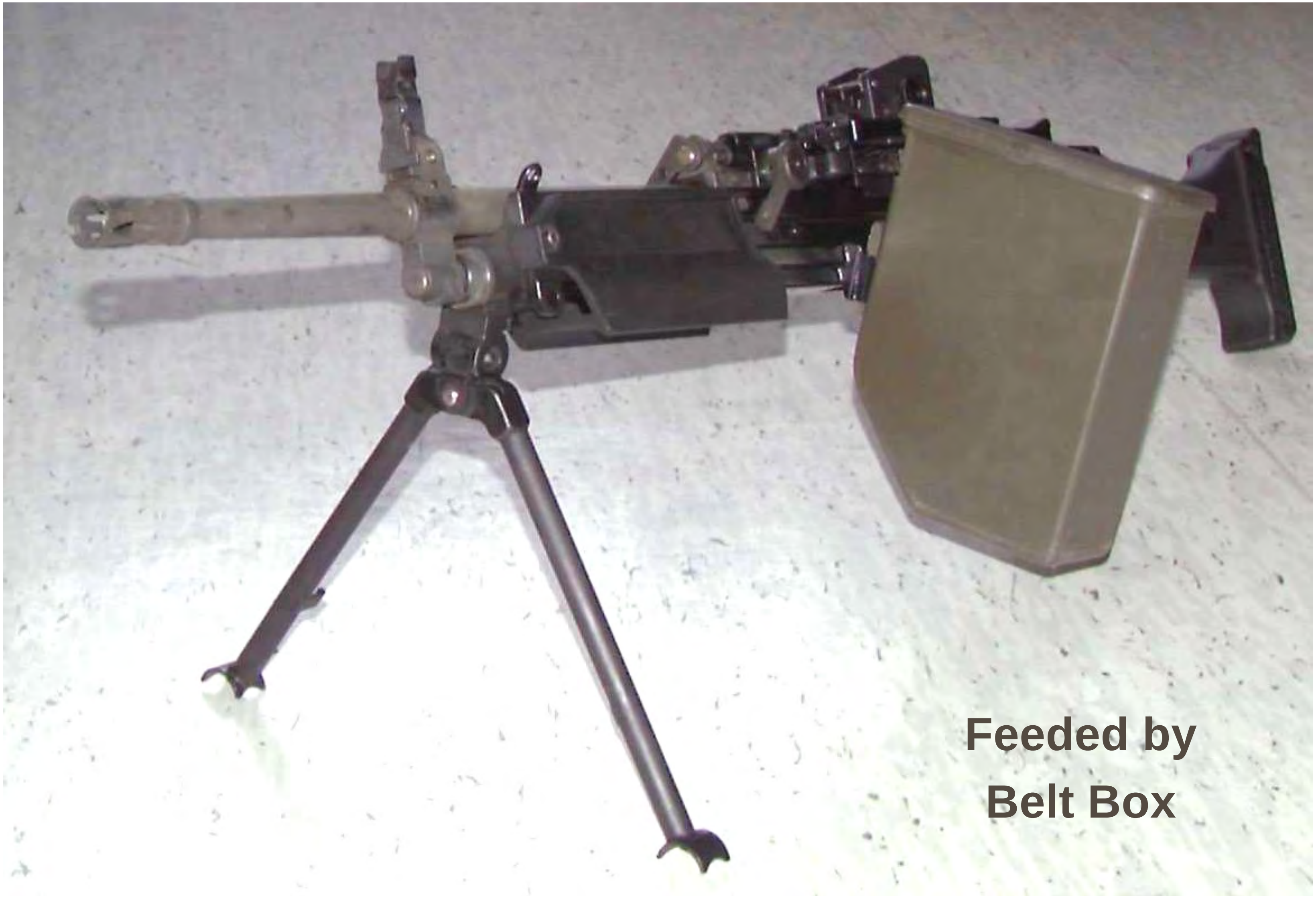
Cal. 5.56 mm x 45

Buttstock Folded



HK - MG43

Cal. 5.56 mm x 45



HK - MG43

Cal. 5.56 mm x 45

HK - MG43

Cal. 5.56 mm x 45

Yuma, Arizona / USA

August 2001

102.000 Rounds Fired

HK - MG43

Cal. 5.56 mm x 45

Endurance Trial over 100.000 rounds

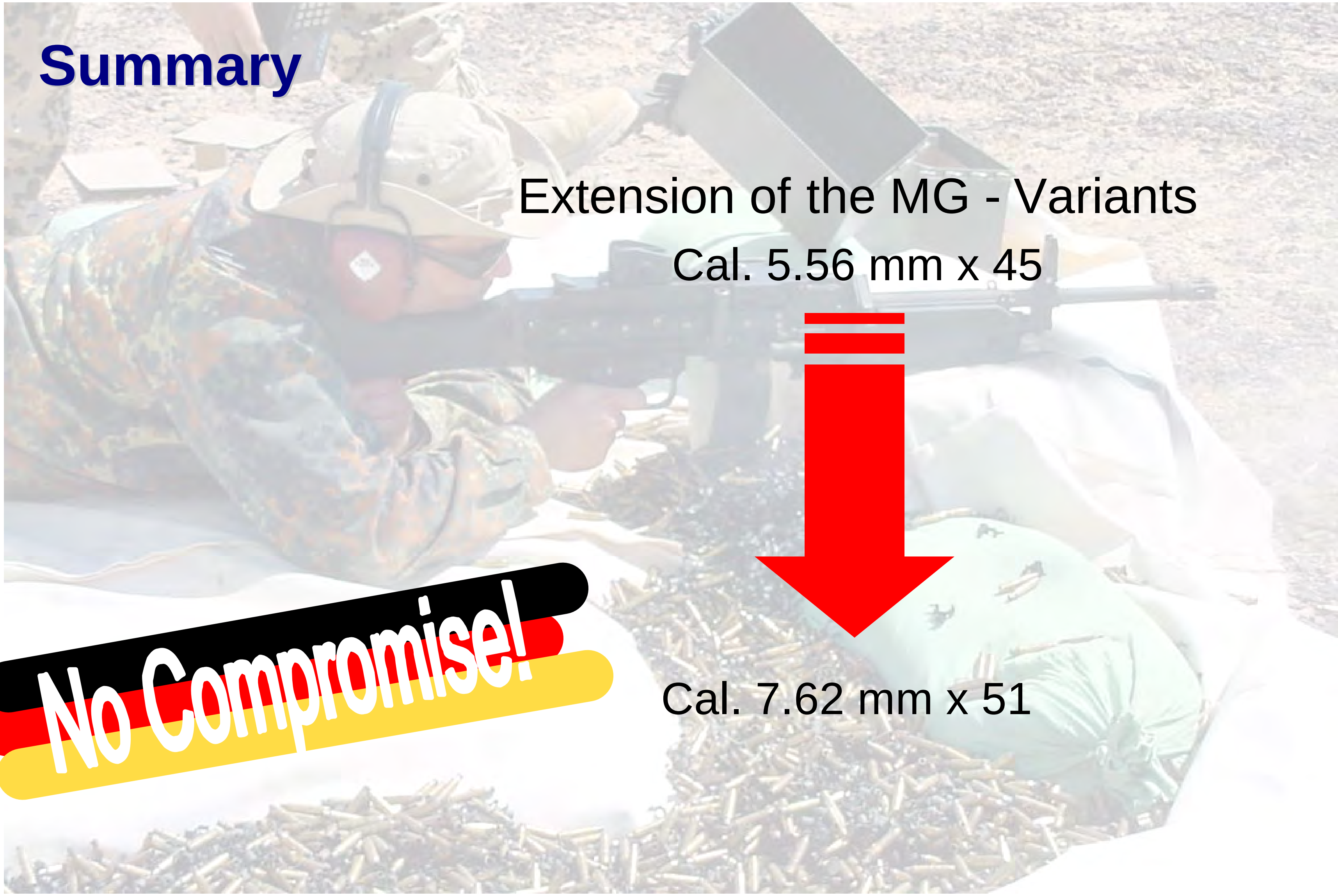
in YUMA, Arizona and Germany, HKO

Summary

- Max Safety For User
- High Functional Safety
  - Reliability
  - Durability
  - Robust System
- Compact Design
- Effective Firing Performance
- Simple and Flexible Handling
- Ergonomics

HK - MG43

Cal. 5.56 mm x 45



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Atlantic City, NJ, 13-16 May 2002

HIGH SPIN ARMOR PIERCING WARHEADS DEVELOPMENT WITH MOLYBDENUM AND TANTALUM LINERS

S.T. McWilliams*, E.L. Baker, K.W. Ng, T. Vuong and R.P. Mazeski
U.S. Army, TACOM-ARDEC, Picatinny Arsenal, NJ USA

ABSTRACT

Exceptional high spin penetration performance is predicted from the computational design of improved high spin armor piercing warheads under the Objective Crew Served Weapon (OCSW) Program. A series of warheads were previously fabricated and tested using OCSW projectile dimensions. These warheads included 20 millimeter diameter high precision liners, 25 millimeter diameter heavy steel bodies and LX-14 high explosive charges. Experimental investigation included flash x-rays and penetration using a high spin testing apparatus designed specifically for the development of high spin armor piercing ammunition warheads. Several of the designs produced good penetration against rolled homogeneous armor (RHA). More recently, the CALE advanced arbitrary Lagrangian Eulerian (ALE) finite difference computer program was used to investigate and design armor piercing warheads using Mo and Ta liners with PAX-2A explosive charges. The objective of the redesign was to provide improved manufacturability, improved safety, and, if possible, increased performance characteristics. The liner materials were selected based on the previous high performance OCSW armor piercing results, including dynamic gun firing tests of prototype armor piercing ammunition. The two dimensional CALE includes spin and material failure, allowing the investigation of both design and spin rate on penetrator formation and radial dispersion. The computations predict the level of penetrator radial dispersion due to high spin, and detonation product impingement during penetrator formation. Computationally predicted reductions in penetrator radial dispersion and increased tip velocities were achieved through liner design considerations. Based on the computational results, a series of increased performance warheads fabrication and testing is currently planned using these newly improved OCSW warhead designs.

INTRODUCTION AND BACKGROUND

In designing an effective shaped charge liner, a high material density is desireable to maximize penetration [Chou 1986]. Molybdenum and tantalum are attractive materials for armor piercing ammunition warheads due to their high material densities (10.2 g/cc for molybdenum, 16.7 g/cc for tantalum) and demonstrated penetration performances [Schwartz 1998, Baker 1998, Baker 1996] in non-spin high performance anti-armor warheads. Copper, which is the traditional material for liners, has a nominal density of 8.9 g/cc, so molybdenum and tantalum would provide denser liners without compromising ductility. Even denser materials, like tungsten (19.2 g/cc), lack the necessary ductility, so the current research focuses on molybdenum and tantalum.

A common inhibitor to penetration in high spin conditions for armor piercing warhead development is radial dispersion of the jet after formation, where the jet loses cohesion under spin conditions (Fig. 1) [Nelson 1995, Weikert 1986, Jameson 1976]. This is a function not only of the

design but also the liner material. Mass matching, where thicknesses are adjusted proportionately to compensate for density differences between materials, will not typically yield similar dispersion results from material to material, so designs must be material specific. Another problem is a phenomenon called the "gaseous guillotine", where detonation products compressed by the shell casing are forced toward the central axis of the cartridge into the jet as it forms and cause discontinuities in the jet. The goal of simulation is to minimize shortcomings in design that would lead to fundamental performance flaws in fabrication.

Radially Dispersed Tantalum Penetrator

Coherent Tantalum Penetrator

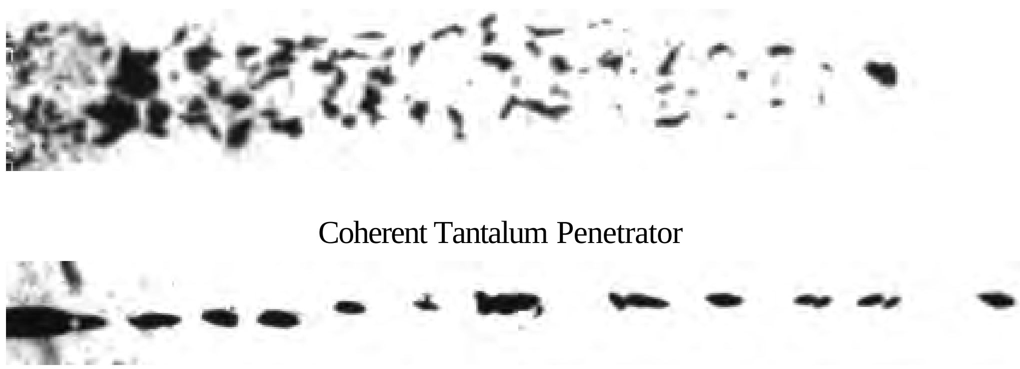

Figure 1. Flash x-ray results of a radially dispersed tantalum penetrator and a coherent tantalum penetrator under high spin conditions. (Baker, Cline, et al, 1998)

TACOM-ARDEC has a long history of anti-armor warheads design and fabrication under the Joint Service Small Arms Program (JSSAP), and current efforts focus on an upgrade to lightweight armor-piercing technology currently used in the small arms like Objective Crew Served Weapon (OCSW), the 30 mm M789, the LW30, and the M203 grenade. Successful testing in both the static spin chamber and through dynamic gunfire have been conducted for OCSW using copper, molybdenum, silver, and tantalum (Baker, Cline, et al, 1998). The focus of this project is the production of a more manufacturable, more IM compliant, and more penetrative warhead design that is still effective over engagement range and at necessary spin rates. The dimensions and configuration of the warhead are the same in all liner redesigns as the original OCSW configuration (Fig. 2).

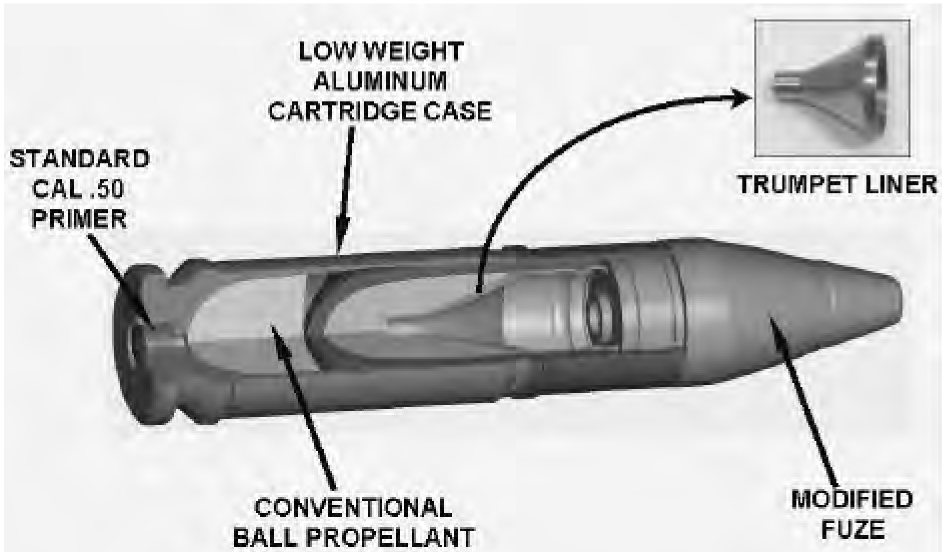

Figure 2. OCSW Armor Piercing Cartridge configuration

<u>DESIGN METHOD</u>

Copper, molybdenum, silver, and tantalum axisymmetric liners in warheads with base-initiated configuration have historically been the focus of investigation. With OCSW, a nose-fuzed configuration was established through a single design iteration, and the subsequent warheads were successfully tested both in a static spin chamber and dynamically with gun-launched testing. The current focus in shaped charge development is the improvement in liner manufacturability, performance, and safety.

The CALE [Tipton 1991] Arbitrary Lagrangian Eulerian (ALE) finite differencing computer program, which is used to create a two dimensional simulation of the performance of a warhead, includes spin and material failure, making it possible for the effects of both design and spin rate on radial dispersion (Fig. 3) and the gaseous guillotine (Fig. 4) to be analyzed.

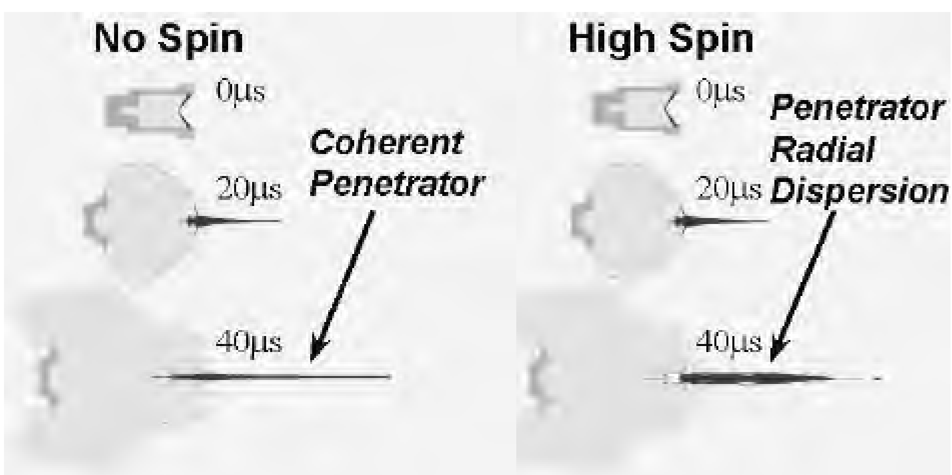

Figure 3. Example of CALE simulation with radial dispersion (Baker, Cline, et al, 1998)

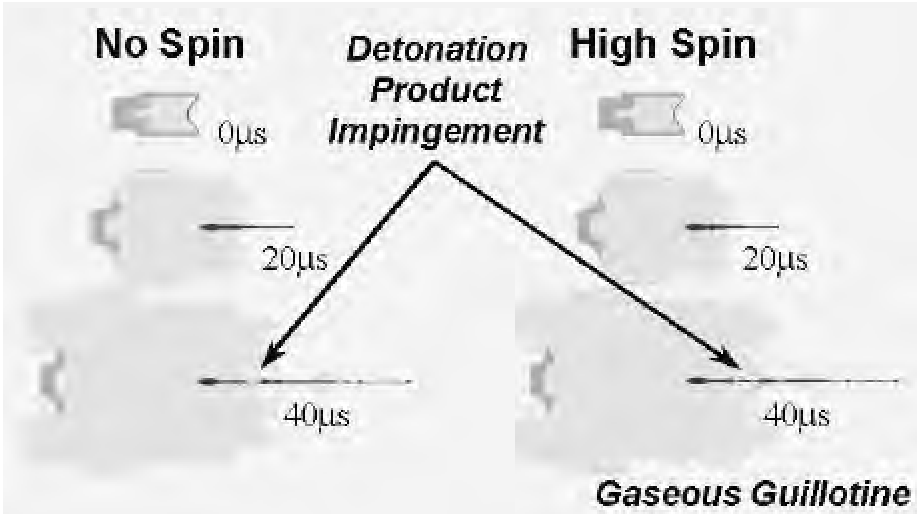

Figure 4. Example of CALE simulation with detonation product impingement (Baker, Cline, et al, 1998)

For this project, CALE was used to design armor piercing warheads with both molybdenum and tantalum liners. The basic warhead geometry was based on the OCSW projectile dimensions, with 20 millimeter diameter high precision liners and 25 millimeter diameter heavy steel bodies. PAX-2A explosive charges replaced LX-14, since PAX-2A is more insensitive munition (IM) compliant, making the round more safe for use in the field.

SIMULATION RESULTS

The original varied-thickness trumpet liner design was run in CALE with both LX-14 and PAX-2A, and a constant thickness design was generated through an iterative process to attain the best possible combination of tip velocity and cohesion for both molybdenum and tantalum with both types of explosive charge. Three slightly different designs yielded the best results for both types of explosive. A slower redesign with even greater stability and less radial dispersion, and a faster redesign with a greater tip velocity were generated. All three redesigns are predicted to outperform the baseline, with the faster redesign having the greatest penetration potential if it maintains coherence when tested (Fig. 5).

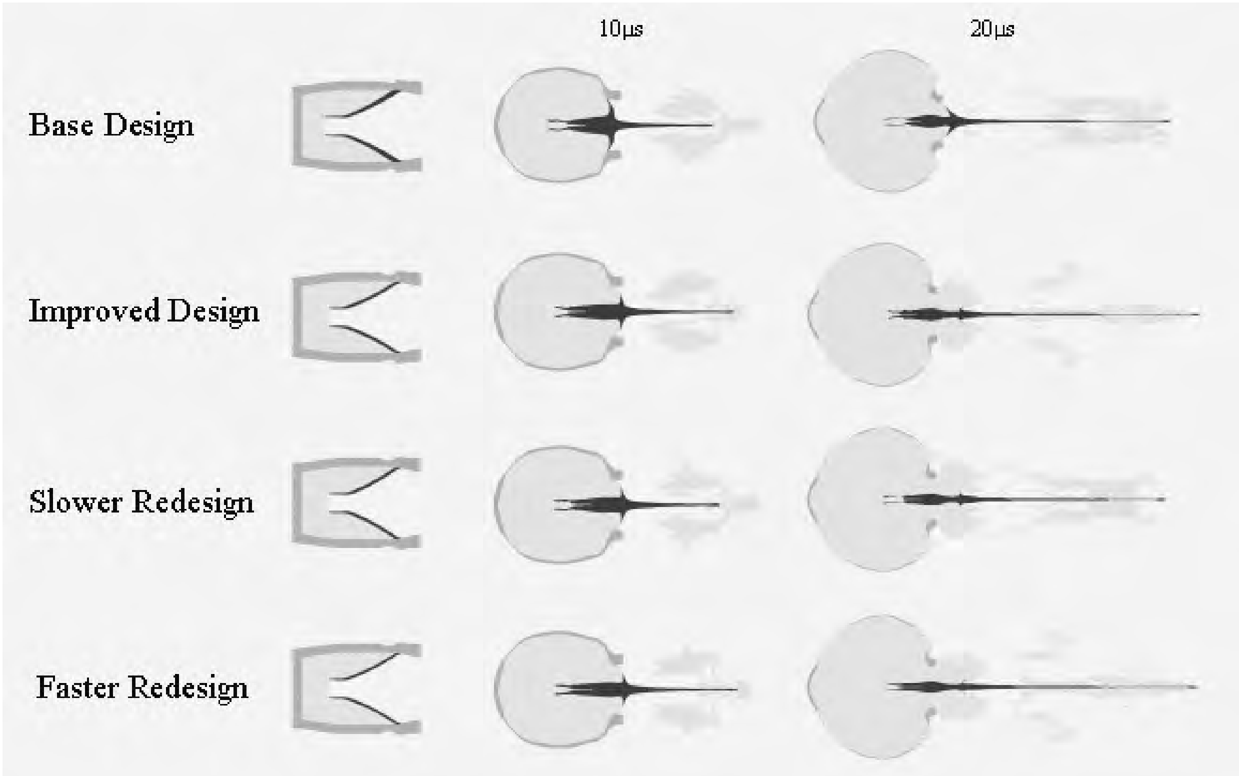

Figure 5. All three redesigns reach higher tip velocities. The slower redesign is more stable and slightly faster than the base, and the faster redesign is less stable but much faster than the base design.

A density profile further illustrates that the slower redesign should have more mass at higher velocities in the jet and have a tip velocity comparable to the base design. The mid-range redesign should yield comparable mass distribution in the jet, and the tip velocity should be significantly greater. The faster redesign has less uniform mass distribution in the jet than the other two redesigns, but if it avoids dispersion, its much higher tip velocity will result in greater penetration performance (Fig. 6).

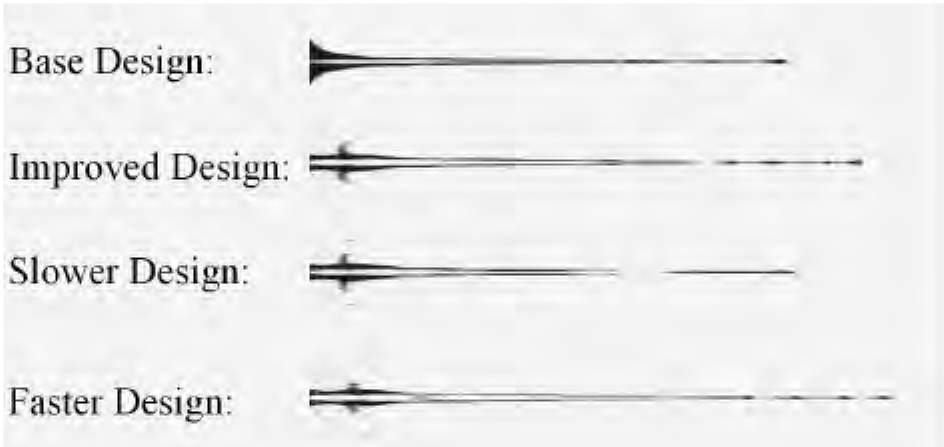

Figure 6. Density profile of the original and the three redesigns. The slower redesign has the most uniform density, while the faster redesign has the higher overall velocity. The mid-range design is the best attainable balance of speed and stability.

The accumulated mass distribution at given velocity further illustrates the predicted increase in performance of the redesigns. Each progressively faster redesign is predicted to have successively more mass moving at higher velocities in the jet, and all three are predicted to outperform the base design (Fig. 7). The faster redesign has the most mass distributed at the highest velocity with the greatest maximum velocity (the tip velocity). The slower redesign, while having the smallest tip velocity of the redesigns, still has a higher tip velocity than the original design while maintaining the smoothest mass distribution throughout the jet of all the designs.

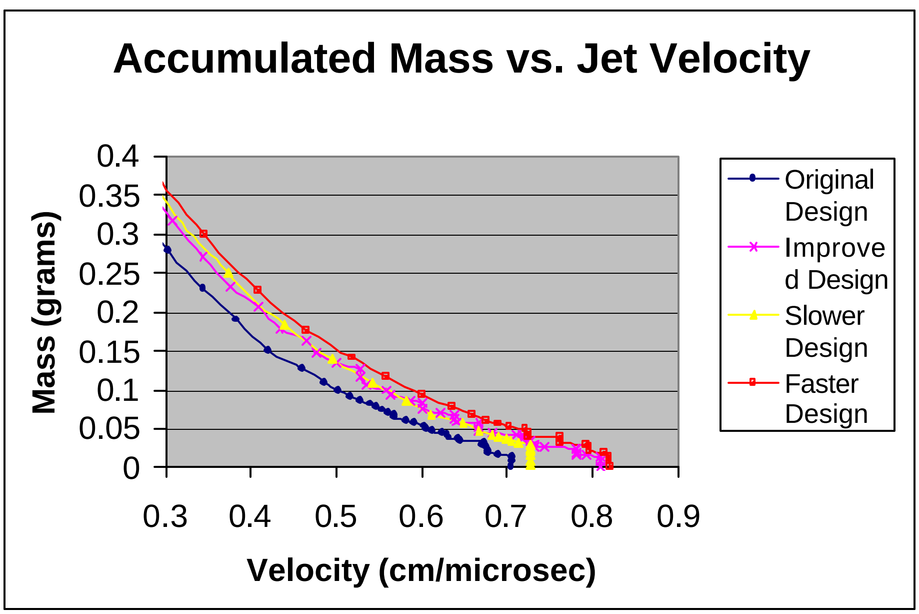

Figure 7. Accumulated mass as a function of velocity for the base design and the three redesign. All three redesigns have more mass at a higher speed in the jet than the original design.

CONCLUSIONS

The original nose fuzed OCSW AP warhead, after undergoing testing, was redesigned with the goal being to increase performance, manufacturability, and safety. A constant thickness redesign was generated and run in a two-dimensional CALE simulation, and is predicted to yield increased performance with a more IM compliant explosive (PAX-2A). Manufacturing methods are currently being investigated for production of redesigns using both molybdenum and tantalum.

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TACOM

Mobility and Firepower for America's Army

HIGH SPIN ARMOR PIERCING WARHEADS DEVELOPMENT WITH Mo AND Ta LINERS

S.T. McWilliams, E.L. Baker, K.W. Ng, T. Vuong and R.P. Mazeski

U.S. Army, TACOM-ARDEC, Picatinny Arsenal, NJ

J·S·S·A·P JOINT SERVICE SMALL ARMS PROGRAM

GENERAL DYNAMICS Ordnance and Tactical Systems

OCSW AP Warheads

Outline

- Introduction
- Background
- Modeling/Design
- Experimentation
- Redesign
- Conclusions

OCSW AP Warheads
Introduction

- **TACOM-ARDEC Warheads**
  - Long history of anti-armor warheads design
  - Technology development
  - JSSAP/GD-OTS OCSW Application
- **AP Ammunition Requirements**
  – OCSW, M789, LW30, M203 upgrade
  – Lightweight AP warheads
  – Effective over engagement range/spin rates

OCSW SC Warheads

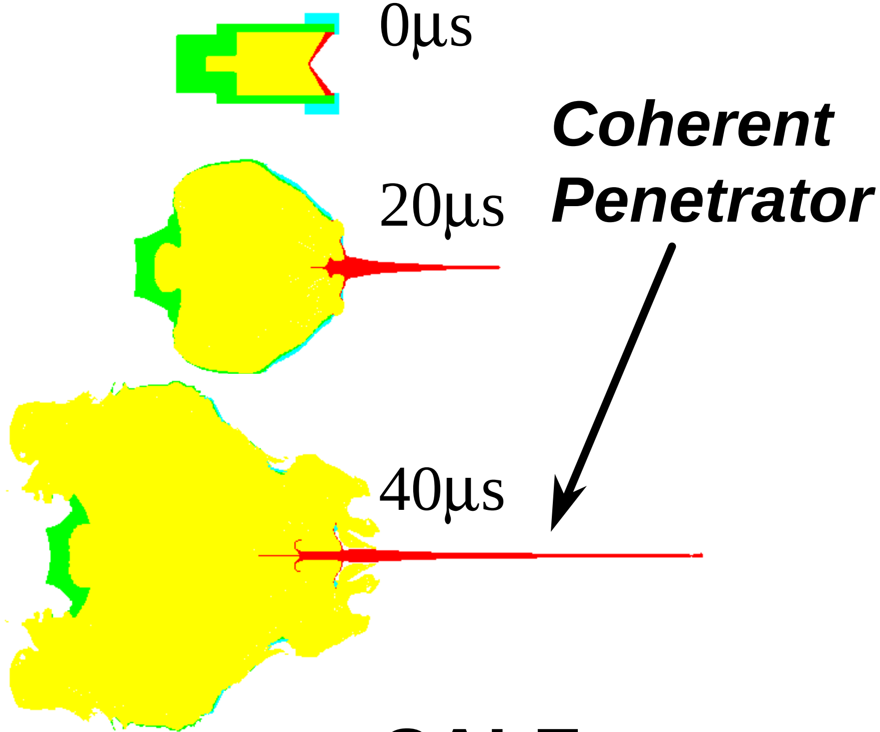
Background

- **Previous Liner material investigation**
  - Cu, Mo, Ag, Ta
  - Primary focus on axisymmetric (cost/time)
  - Base initiated configuration
- **Previous OCSW AP Development**
  - Change to AP nose fuzing: Single design iteration
  - Static spin and gun launched testing completed
- **Current SC focus**
  - Modeling/design development
  - Liner producibility, increased penetration

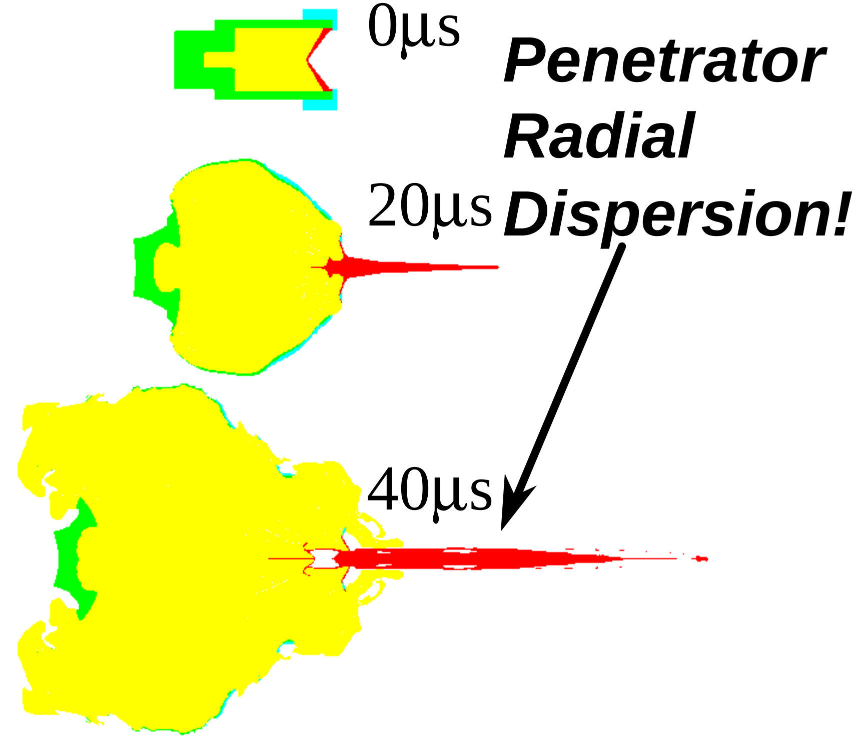
OCSW AP Warheads

High Spin Penetrator Dispersion

No Spin



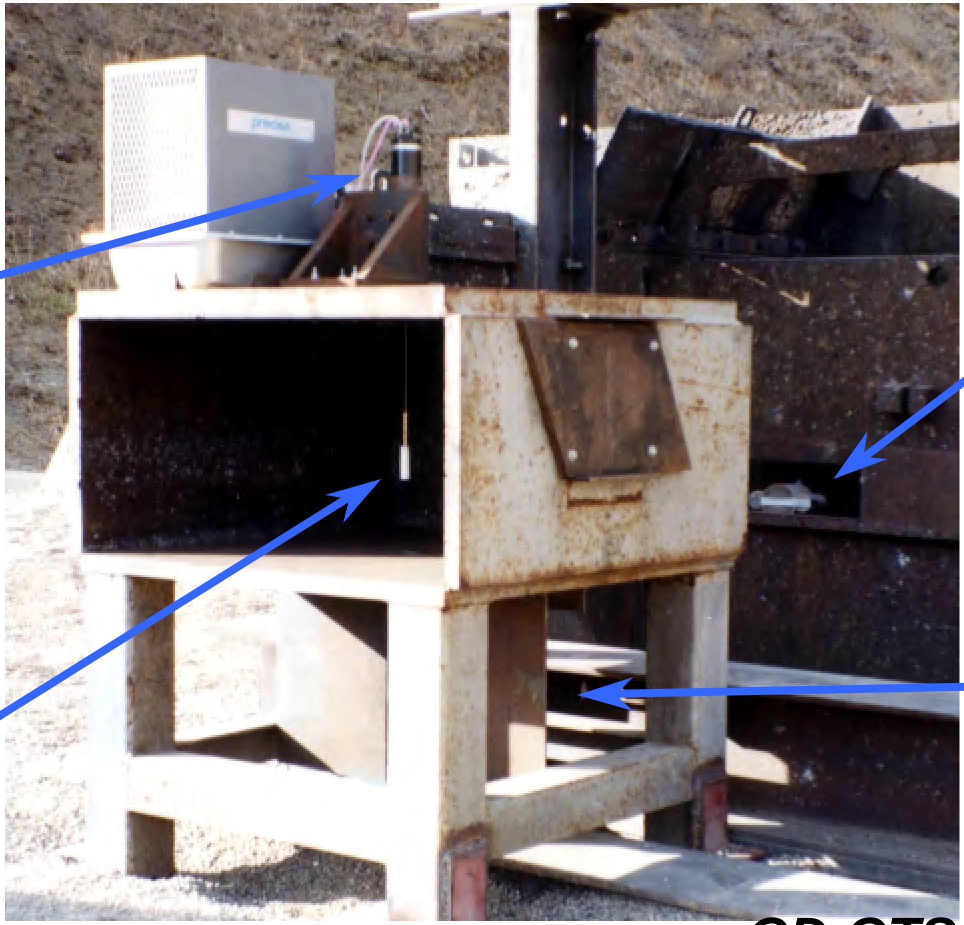
High Spin



- **CALE**
  - Explicit Finite Difference Program
  - 2D Arbitrary Lagrange Eulerian (ALE)
  - Failure, Spin

OCSW AP Warheads

High Spin Test Stand



Spin Motor

X-Ray Head

Warhead

Target/Film Area

GD-OTS Test Facility

OCSW AP Warheads

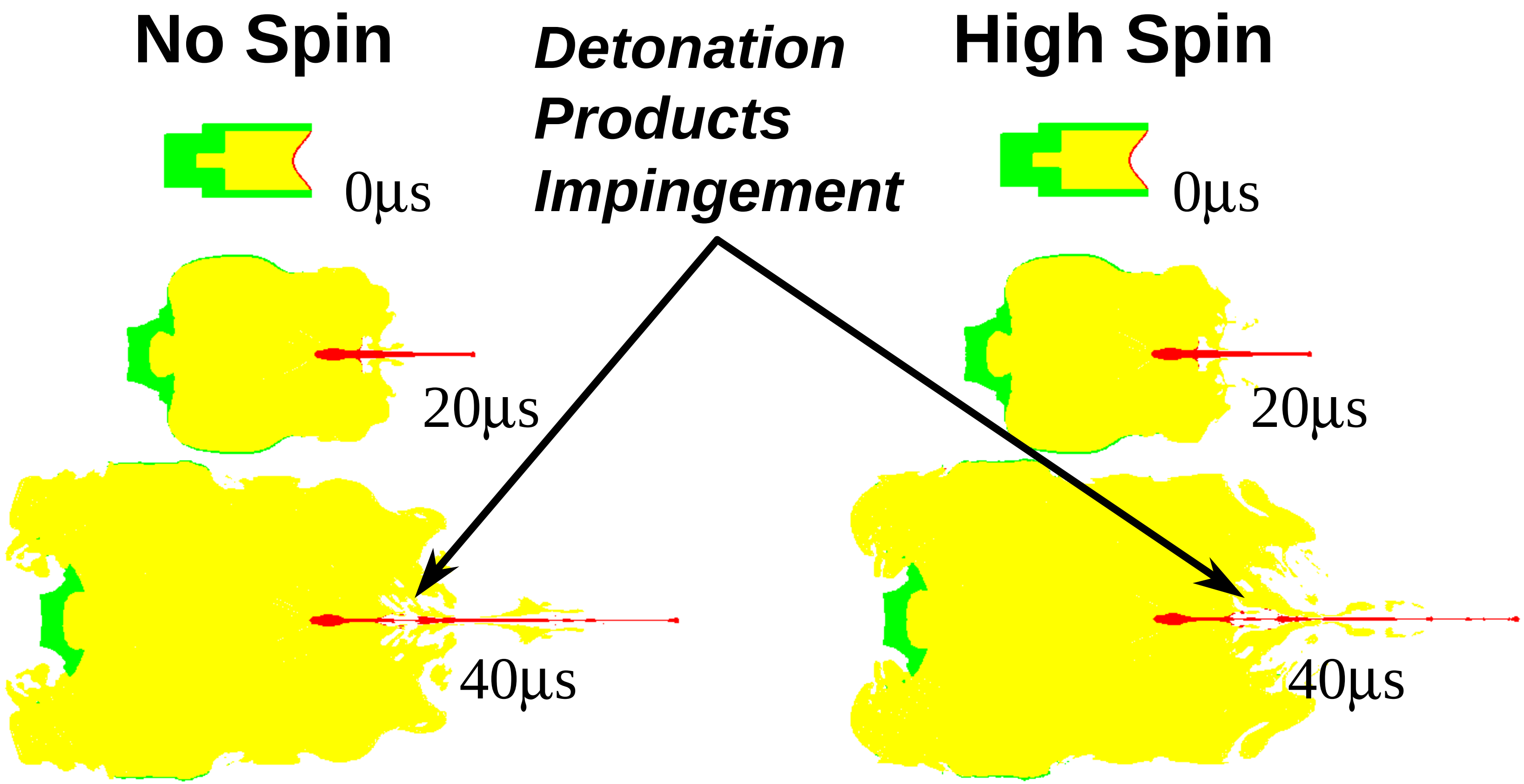
Flash X-Rays

Baseline Warhead

Excellent Modeling/Experimental Agreement!

OCSW AP Warheads

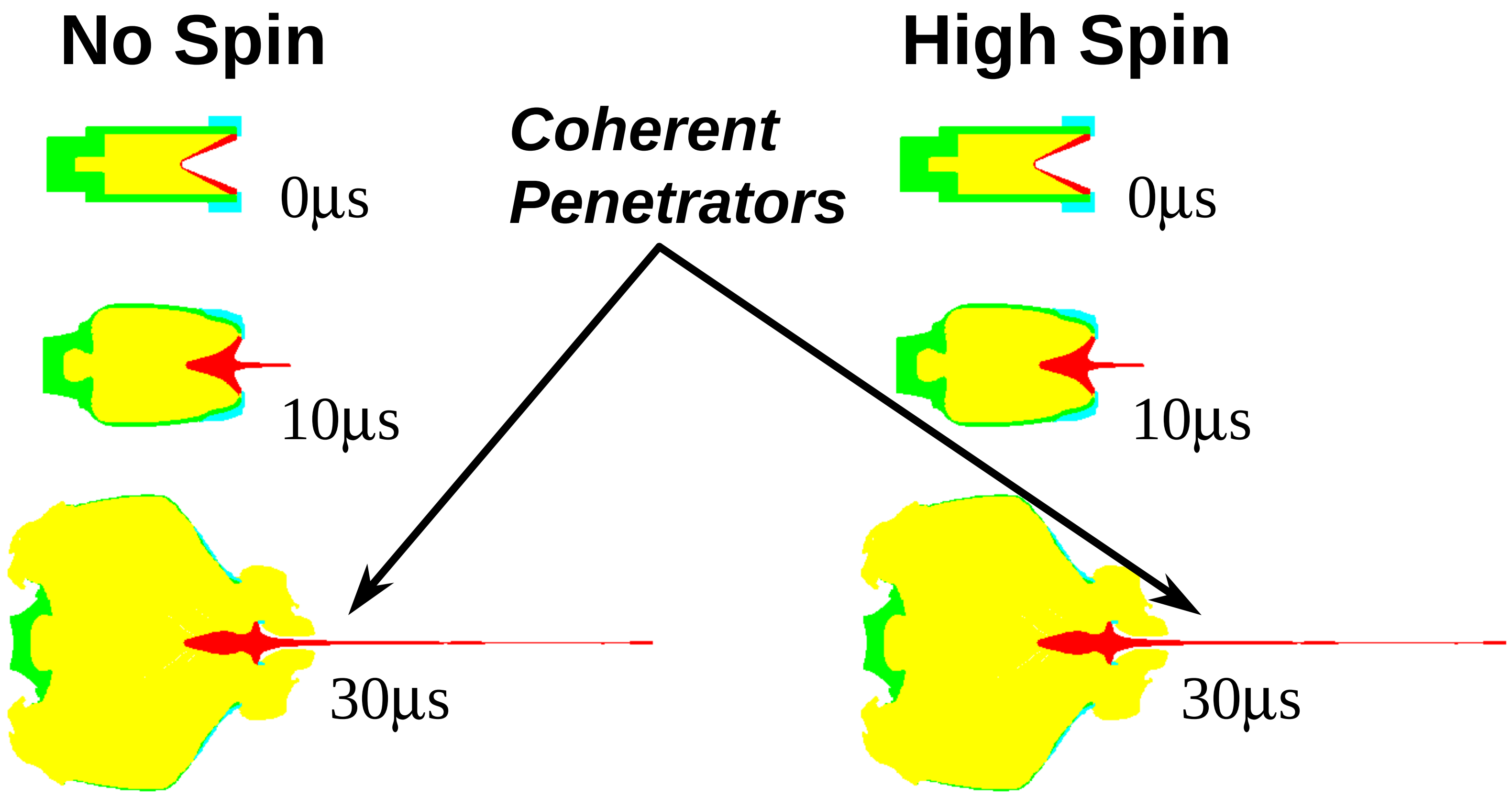
Products Impingement



Gaseous Guillotine!

OCSW AP Warheads

High Spin Coherent Penetrators



Nearly Identical Unperturbed Penetrators!

OCSW AP Warheads

Flash X-Rays

Radially Dispersed Copper Penetrator

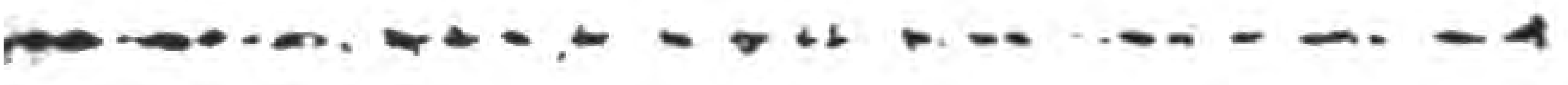
Travel Direction

Radially Dispersed Tantalum Penetrator

- ***Radial dispersion depends on both design and material***
- ***Mass matching of designs doesn't work***

OCSW AP Warheads

Flash X-Rays



Coherent Molybdenum Penetrator

Travel Direction

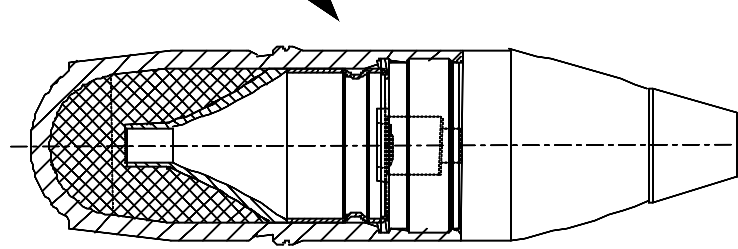
Coherent Tantalum Penetrator

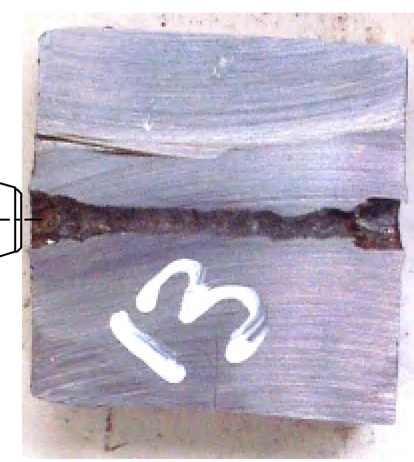
Design must be appropriate for the material!

OCSW AP Warheads

Original Nose Fuzed Design

Trumpet Design

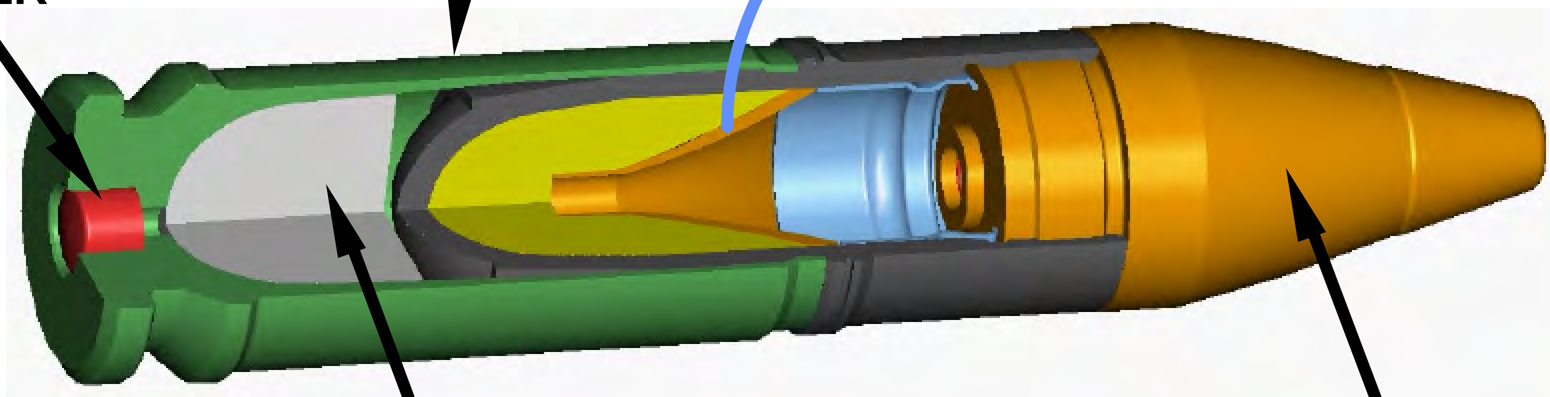




- Single Iteration Nose Fuze
- Trumpet Liner
- LX-14 Explosive
- Static Spin Testing
- Dynamic Gun Testing

OCSW AP Cartridge

Dynamic Test Configuration

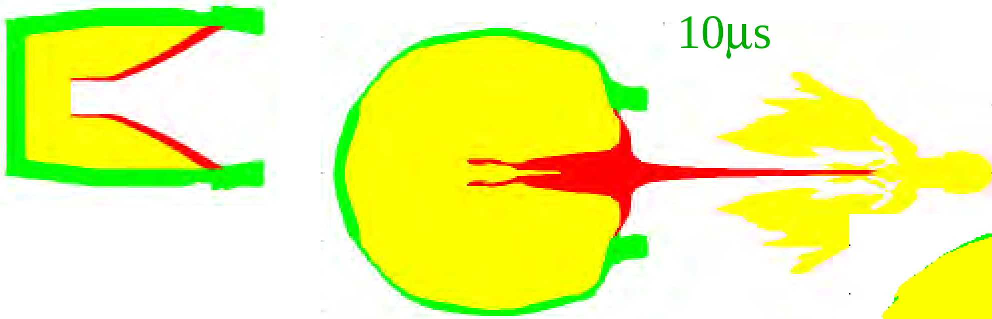


OCSW AP Redesign

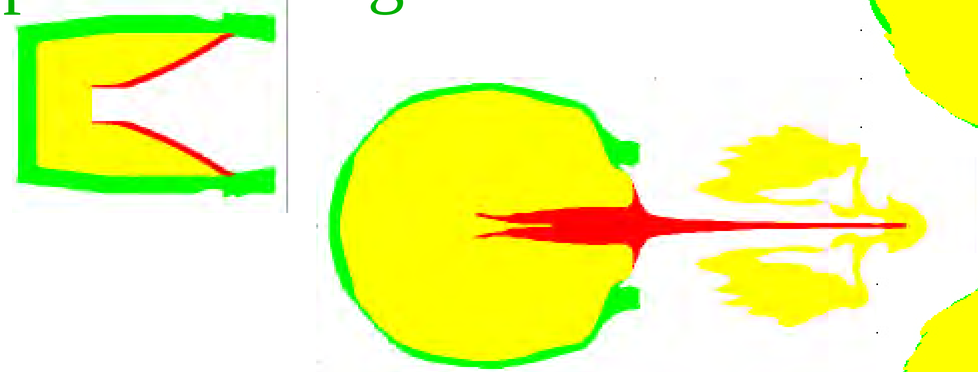
Original Design

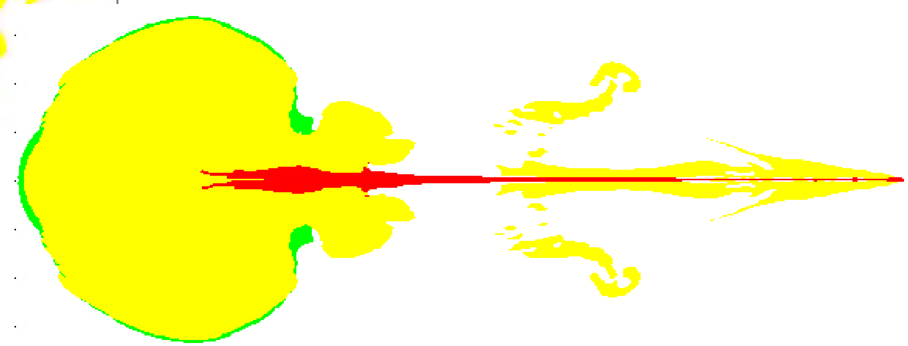
10µs

20µs



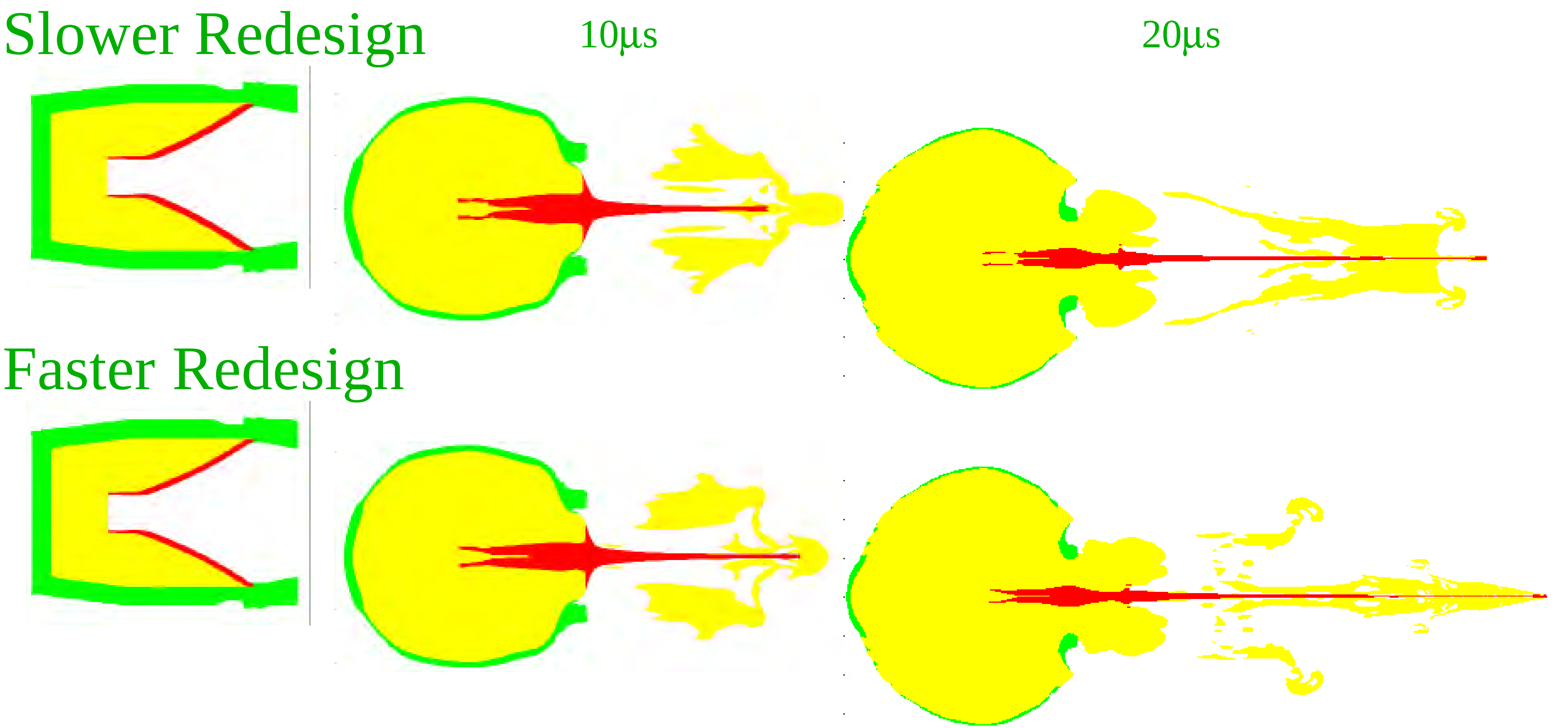
Improved Design





- *Improved Manufacturability!*
- *IM Explosive (PAX2A)*
- *Increased Performance!*

OCSW AP Redesign



•*Slower design yields increased stability*

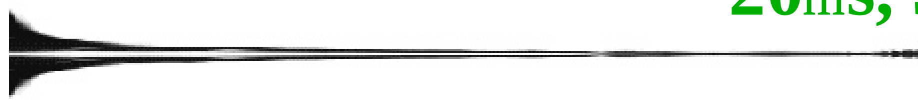
•*Faster design, if stable, has greater penetration potential.*

OCSW AP Redesign

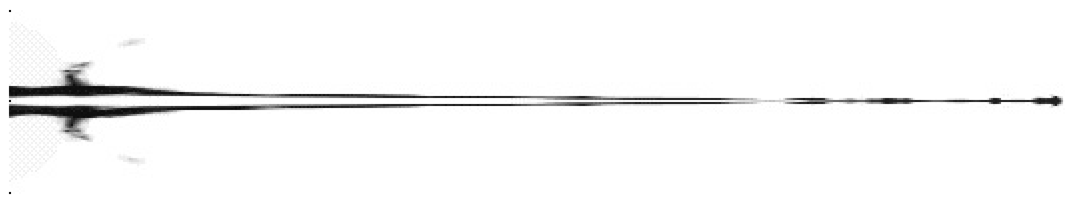
Density Comparison of Designs at High Spin

20ms, 500rps

Original Design:

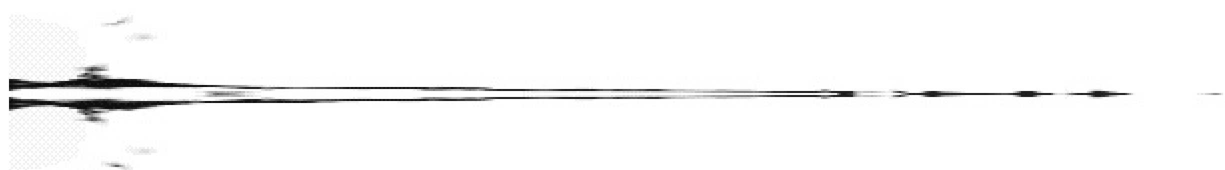


Improved Design:



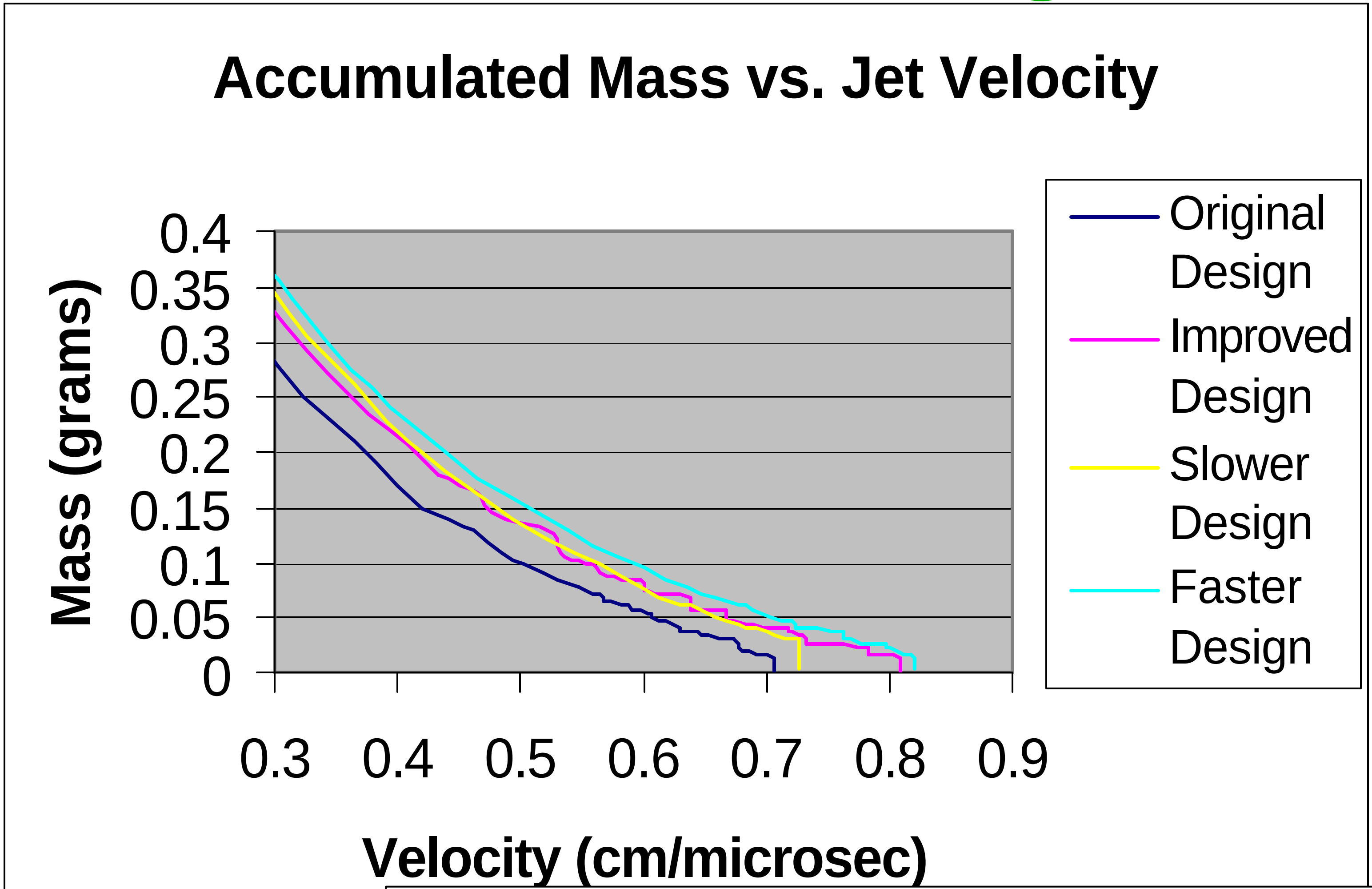
Slower Design:

Faster Design:



- *Slower design undergoes less radial dispersion*
- *Faster design attains a higher jet velocity*

OCSW AP Redesign



All three new designs are predicted to provide increased performance!

OCSW AP Redesign

Conclusions

- OCSW AP Original Design
  - –Nose fused
  - –Static Spin Testing
  - –Dynamic Gun Firing Demonstration
- OCSW AP Mo and Ta redesigns complete.
  - –Improved manufacturability
  - –IM explosive (PAX2A)
  - –Increased predicted performance
- Manufacturing methods investigation underway

NDIA Small Arms Symposium

Multi-Sensory Deprivation "Land Mine"

Mr. Harry Moore
U.S. Army TACOM-ARDEC
Advanced Armaments Technology Team
AMSTA-AR-CCL-D
973-724-7932

14 May 02

Multi-Sensory Deprivation Device (MSDD)

Sized to
M139 Volcano Dispensed Munition
&
M16A2 Hand Emplaced "Bouncing Betty"

- **Concept of Operation:** Develop an acoustic device that can be used for distracting, and delaying individuals.
- **Scenario:** Provide a NL alternative capability for protection of Anti-Tank (AT) mines
- **Technologies:** Multi-Sensory Deprivation utilizing aversive sound and light. Rapidly emplace minefield for high reliability acoustic aversive device for delay of threat

Outline

- Objectives
- Background
- Leveraging
- Approach
- Modeling / Simulations
- Operational Capabilities
- Effects (Candidate Aversive)Sounds
- Human Effects
- Program Summary
- Future Efforts

Objectives

- **Program Objectives**: To demonstrate the scalability of multi-sensory deprivation technology for application in a single Volcano and M16A2 hand-emplaced mine configuration.

- **Technical Objectives**:
  - Identify aversive sounds & aversive sound qualities
  - Quantify aversiveness & neurobehavioral impact
  - Assess combined effects of light and sound across scenarios

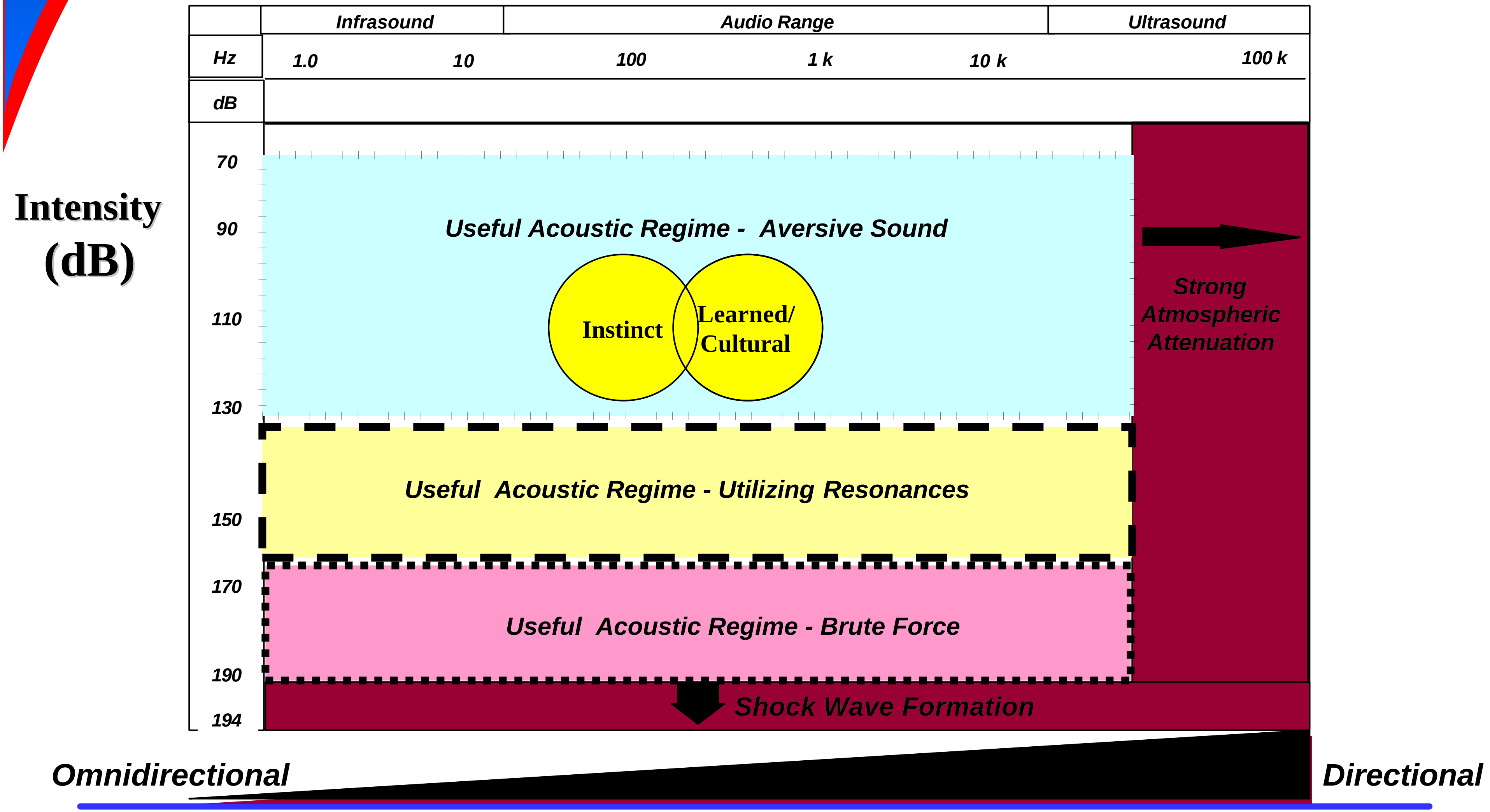
- **Performance Objective**:
  - Fabricate a breadboard to support concept demo

Background

- Leveraging from multiple efforts & APLA Track III
- Previous NL programs (e.g., Bounding NL Munition)
- **CONCEPT**: Focus on combined Acoustic & Light technology

- ***WHY ACOUSTICS****?*
  - Focus on *minimizing* probability of lethal effects
  - Capability to *tune* acoustic approaches to non-lethal levels while still maintaining a *high probability* of adverse effects generating functional delay
  - Availability of designs with *reasonable* size and power requirements for potential weapon solutions

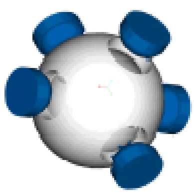
Useful Acoustic Regime

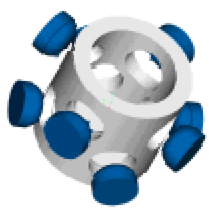


Approach

• Adapted Audible Aversive Acoustic Device (A3D or Gayl Blaster) concept for Anti-Personnel Landmine Alternative

- Body designed body in Pro-E and produced with stereo lithography





- Breadboard system uses a rack mounted signal source to provide flexibility
  - Pure tones with adjustable frequency, amplitude, modulation
  - Complex User/Computer generated waves

Approach (cont'd)

- Original Concept Investigated only Acoustics
- In an effort to maximize effectiveness, it was determined that multiple sensory deprivation would significantly improve battlefield performance, within same weight and cube
- Effects
  - Audible and visible light Ranges
  - Non-Injurious Effects
  - Behavior Modification
  - Effects <u>not</u> Intensity Based
- Countermeasures
  - Audible - Hearing protection <u>not</u> effective
  - Light: Auto closing visor may be effective, but would significantly reduce threat capability(s)

Approach (cont'd)

- Extensive literature search performed, investigating any (anecdotal and proven) information available on the subject of the 'human auditory response'.
- Identified the characteristics of sound that can be manipulated.
- Obtained mandatory Internal Review Board approval to begin auditory response testing.
- Assembled an in-house sound lab, which allowed the researchers to personally explore and exploit these 'dimensions' of sound via customized sound file creation.
- Secured testing equipment and developed test plans tailored to gauge the 'human auditory response' to given auditory stimuli.

System Simulations

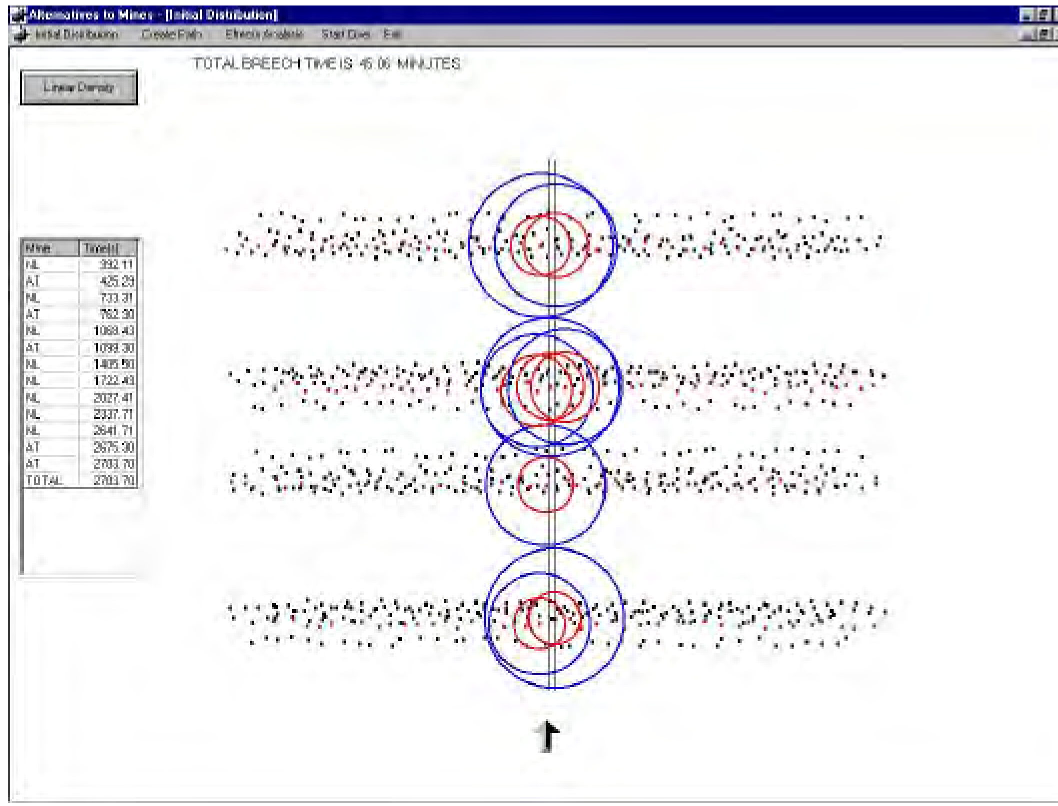
<u>System simulations for typical mission scenarios</u>

- Goal of simulations:
  - Evaluate the effectiveness of technologies
  - Define requirements for the acoustic source
    - –*Number of sources*
    - –*Placement density*
    - –*Source frequency*
    - –*Intensity*
    - –*Duty cycle*
    - –*Lifetime*
  - Screen candidate concepts

Modeling & Simulation

- Developed preliminary design tool (leveraged from SHM)
- Visual based tool investigates
  - Dispensing Schemes
  - Countermine Effectiveness
  - Acoustic Range Effects
- Example inputs include
  - VOLCANO
  - Fraction of NL Devices
  - Effective Radius, Duration and Trip Wire Extent
- Tool utilized to perform simple performance trades

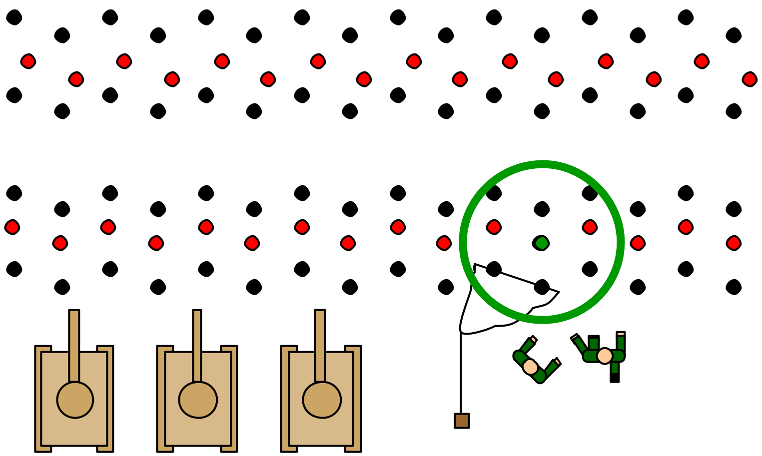
Non-Lethal Technology Analysis Tool (NLTAT)



Modeling & Simulation

Preliminary Performance Trades

●AT Mine ●NL Mine ●Activated NL Mine



<u>Baseline Parameters</u>

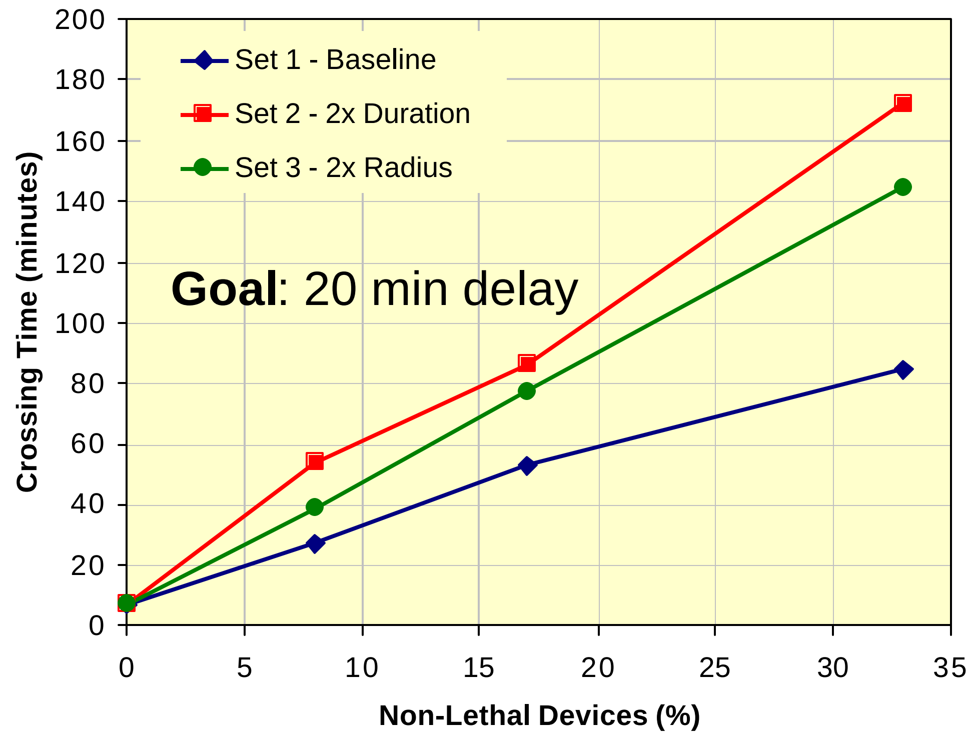
Effects Duration: 5 minutes

Effective Radius: 25 ± 5m

Trip Radius: 10 ± 2m

Traverse Speed: 3 m/s

AT Disable Time: 30 s



- Trade Between Effects Duration and Number of NL Devices
- Trade Between Effective Radius and Number of NL Devices

Operational Capabilities

- **Primary:**
  - Disrupt Task Performance Resulting in Delay
- **Secondary:**
  - Increased Comfort Zone Between Friendly Forces/Equipment and Threat
  - Potential to Contain/Reduce Escalation Factor
  - Provides Force Protection
  - Non-combatant Dissuasion

Multi-Sensory Deprivation Device

- Assembled using modified off-the-shelf piezo's and strobe
  - Approximately 20 watts to generate 112 dB_{RMS} @ 1 meter with 8-piezo system
- Assembled a 4-piezo systems with integral signal source
  - Generates 93 dB_{RMS} @ 1-meter using two 9-Volt Batteries

Human Effects

- In General – there are documented cases of light and sound phenomena, they are scenario/application specific

- Current literature review, indicates that little if any applications have utilized both light and sound in combination
    - Most importantly, not for this type of application

Program Summary

- Program objectives accomplished:
  - Scalability of Technology Demonstrated
  - Generation of the Combined Effects of Sound and Light
- Modeling
- Established Technology Assessment Matrix
- <u>Issue</u>: Bio-effects testing is deficient/non-existent specifically investigating behavior modification

Future Efforts

- Candidate sounds for future investigation:
  - **Aversive sounds**
  - **Sound and light which simulate special effects**
    - **Gun shots, rockets/missiles, mines/explosives detonating**
  - **Recognizable sounds**
    - **Normal communications or commands**
      - **In English or in language of RED troops**
    - **Screams, warbles**

- More efficient acoustic drivers
  - **Explore HyperSonicSound (HSS™) Technology**

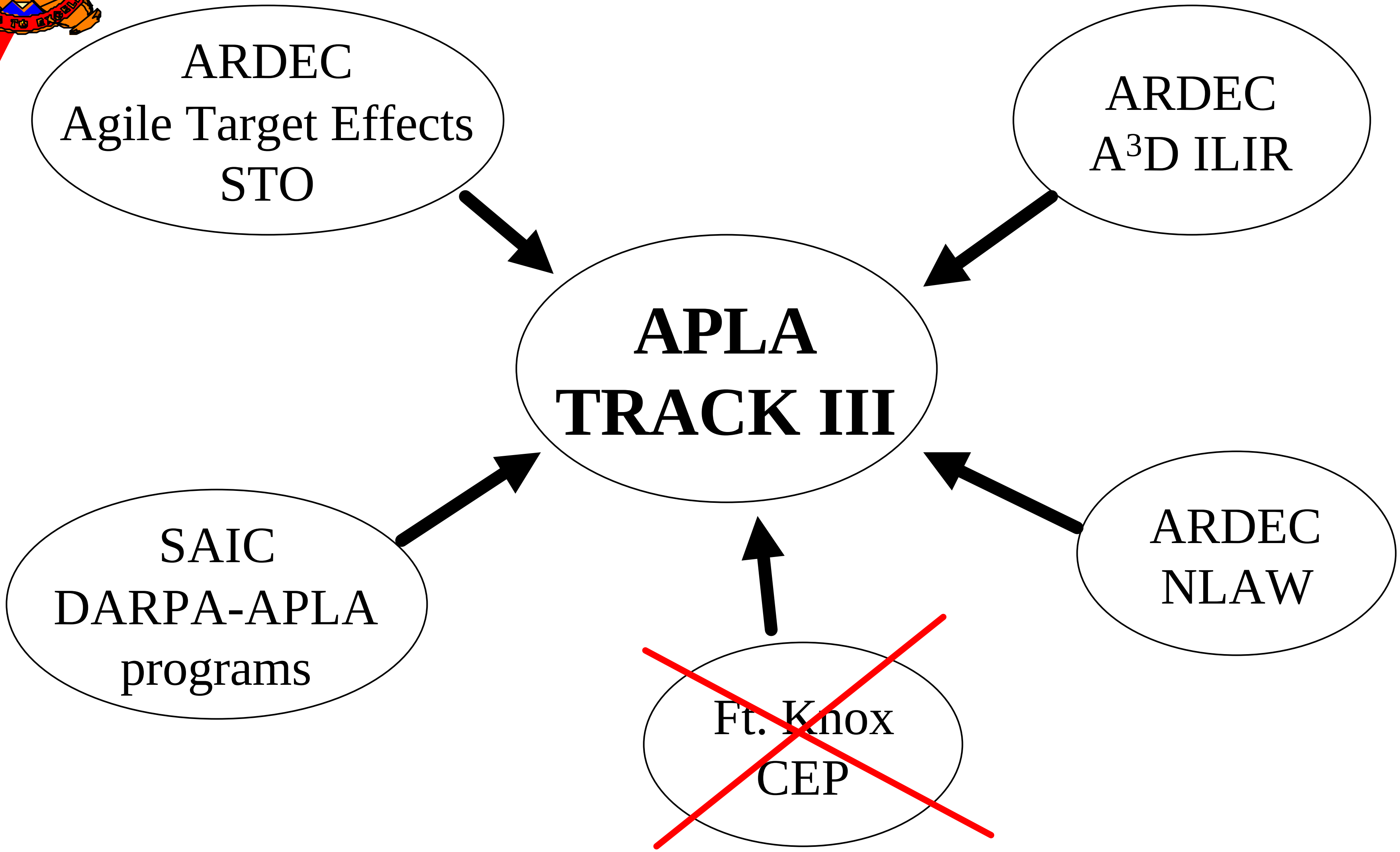
- Electrically and/or mechanically rotate or direct sound

Future Efforts

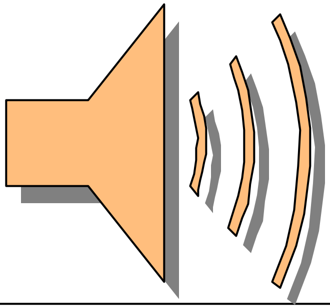
- Integration / Development of Activation Sensor (or Fuze)
  - Hand emplaced
  - Platform launched / dispensed
- Volumetric Concerns (Power Needs vs Volume Limits)
- Integration of Self Righting Technology
- System Integration
- Prototype fabrication and testing against established performance parameters & effects determination
- Bottom Line: Additional funding would be required to continue the weaponization of this technology

Back-Up Slides

Program Leveraging



Acoustics Primer



How does acoustics work?

- Acoustic energy/power is generated by compressing a medium (in this case air) to create a pressure wave
- Acoustics are similar to mm/microwaves in many areas

Advantages of Acoustics

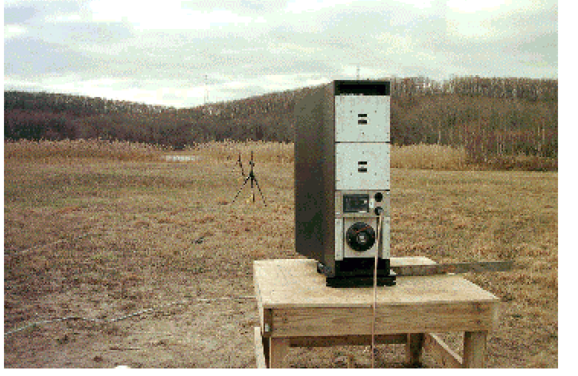
- Can be directional, depending upon frequency
- Naturally provides area coverage, and hence area denial
- Can provide tunable target effects
  - Anti-personnel/anti-materiel
- Weather conditions
  - High relative humidity improves performance – not required
- Countermeasures
  - Non-aural target effects have few if any countermeasures
- Non-polluting

Disadvantages of Acoustics

- Frequency
  - High frequency
    - Increased atmospheric attenuation
  - Low frequency
    - Reduced directionality to omni-directional
      - Potential for increased fratricide
    - More energy/power from source which increases system weight/volume and logistics burden
- Effects data – mostly anecdotal
  - On-going efforts to gather data

Types of Sound Generation Sources

- **Piezo - Electric**
  - *High Performance Speakers & Ceramics*
  - *Smallest Volume Package*
  - *Promising, Additional Work Needed*
  - *Shortest Range against Single/Few Targets*



- **Compressed Air Driven**
  - *Sirens*
  - *Cover Larger Area*
  - *Brassboard Available*
  - *Can Be Made Directional*

- **Combustion Driven**
  - *Pulser, Siren, Flame Tube Vortex, Detonation Tubes*
  - *Cover Larger Area*
  - *Brassboard Available*
  - *Can Be Made Directional*

U.S. Army Materiel Command

Mr. Gary Motsek

Army Munitions Readiness

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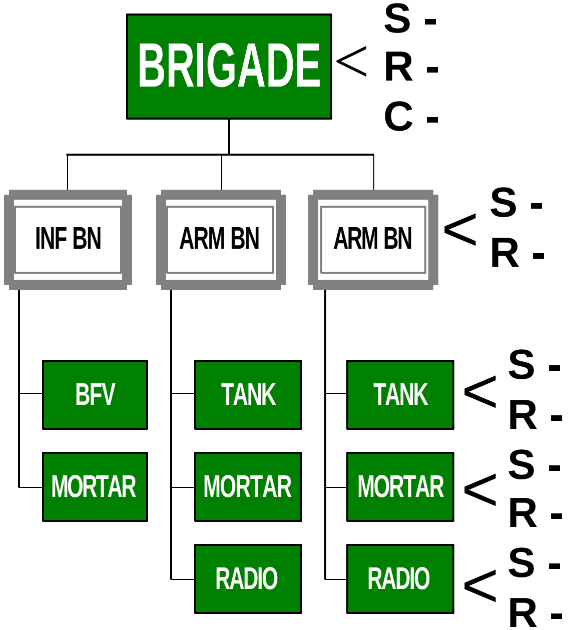
15 April 2002

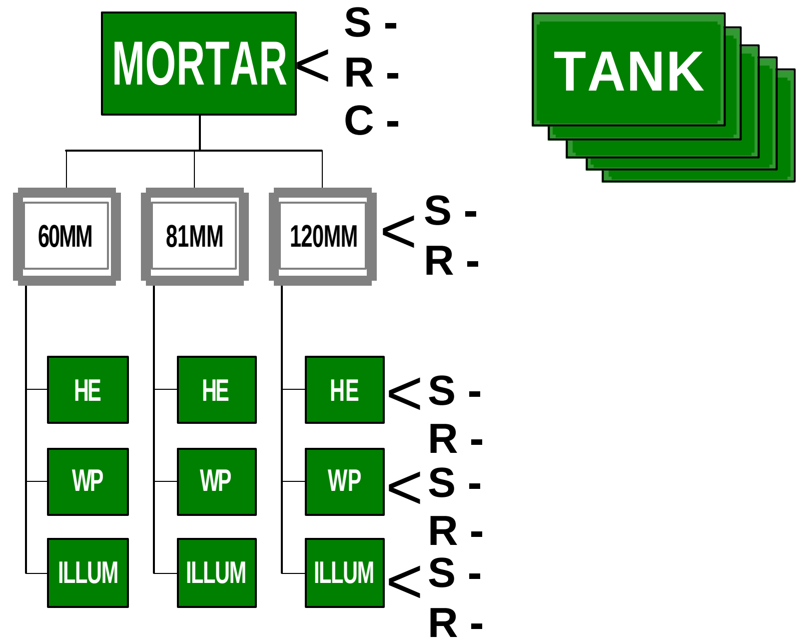
AMERICA'S ARSENAL FOR THE BRAVE

Munitions and Unit Status Reporting
(AR 220-1)

Unit Status Reports
Unit View



Munitions
Worldwide View

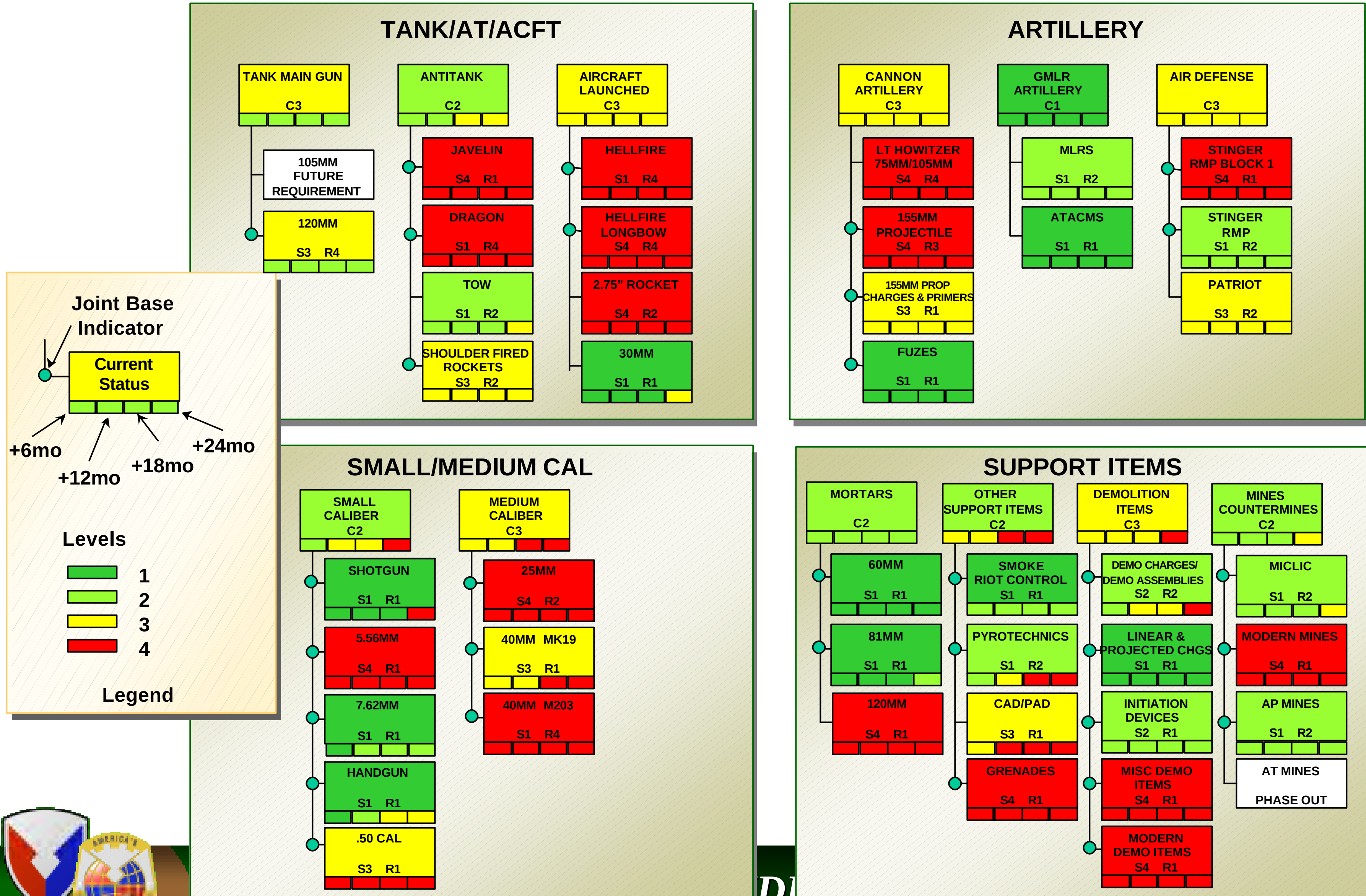


- Rate individual items
  - S - On hand
  - R - Serviceability
- Group by Battalion
- Composite at Brigade

- Rate individual items
  - S - On hand
  - R - Serviceability
- Group by Sub-category
- Composite at Category

Army Munitions Readiness
Worldwide View

As of 31 Mar 2002



Aircraft Launched

As of 31 Mar 2002

Category	Current			+6	+12	+18	+24
	S-	R-	C-	C-	C-	C-	C-
Acft Launched	3	3	3	3	3	3	3
HELLFIRE	1	4	3	3	3	3	3
LONGBOW	4	4	4	4	4	4	4
2.75 Inch Rkts	4	2	4	4	4	4	4
30mm	1	1	1	1	1	1	3

- ***HELLFIRE***
  - (Includes all laser DODICs PD68, PU72, PV29, PV30 against overall HELLFIRE II WARREQ)
  - Quantity in Condition Code N causes R4 rating –subjectively upgraded to C3 due to large available quantities
- ***LONGBOW***
  - Procurement objective of 12,905 is less than LONGBOW QWARRM07
  - Five units fielded have 100% of UBL (Condition Code N, War time use only)
- ***2.75 Inch Rockets - MPSM and HE/RS shortfall***
- ***30MM – Projected shortfall of 30mm TP***

Small Caliber

As of 31 Mar 2002

Category	Current			+6	+12	+18	+24
	S-	R-	C-	C-	C-	C-	C-
Small Caliber	2	1	2	2	3	3	4
Shotgun	1	1	1	1	1	1	4
5.56mm	4	1	4	4	4	4	4
7.62mm	1	1	1	1	2	2	2
Handgun	1	1	1	1	2	3	3
.50 Caliber	3	1	3	4	4	4	4

- *5.56mm*
  - SAW linked and M16A2 Rifle training ammo shortfall
  - Buying to historical training; Higher projected training
- *Handgun ammo – Projected shortfall of .22 Cal Match*
- *.50 Caliber*
  - SLAP and MK211 shortfall
  - Projected shortfalls in linked training ammo; Historical vs. projected

FY02 increase not yet applied
DERF: $72M
PAA: $26M

Army Munitions Readiness

As of 31 Mar 2002

Munitions Categories

Category	*Rating*
Tank Main Gun	C-3
Anti-Tank	C-2
Aircraft Launched	C-3
Cannon Artillery	C-3
GMLR Artillery	C-1
Air Defense	C-3
Small Arms	C-2
Medium Caliber	C-3
Mortars	C-2
Support Items	C-2
Demo Items	C-3
Mine-Countermine	C-2

Munitions Functions

Function	*Operational Requirement*	*Rating*
Call forward	• OCONUS training • OCONUS modernization	C-4
Retrograde	• CONUS training • Free up space in Korea	C-4
* CONUS distribution	• CONUS training	C-3
* Readiness Inspections	• Identify/confirm true condition	C-2
Maintenance	• Generate useable assets	C-3
* Inventory	• Accountability	C-2
* Production Base	• Ability to produce	C-3

*** Impacts all Services**

Army Munitions Readiness Summary

- ***Developed comprehensive ratings***
  - **Real data**
  - **End of March data**
  - **Includes all munitions (Ammo and Missiles)**
- ***Identifies focus areas for munitions***
- ***Planned quarterly updates – Flasher reports as appropriate***

BACKUP SLIDES

Tank Main Gun

As of 31 Mar 2002

Category	Current			+6	+12	+18	+24
	S-	R-	C-	C-	C-	C-	C-
Tank Main Gun	3	4	3	2	2	2	2
105mm	Future		6	6	6	6	6
120mm	3	4	3	2	2	2	2

- ***105mm Gun***
  - DA computing future requirement (WARREQ 09)
- ***120mm Gun***
  - War fighting cartridge fill is good: APFSDS-T M829A2 at 89%, HEAT-MP-T M830A1 at 92%
  - S3 rating due to Obstacle Reduction Ctg. Shortfall eliminated with June 02 deliveries
  - R4 rating due to 136k Unserviceable M865 KE Training Ctg – 29k funded for FY 02 Maint; Balance of unserviceable will be provided as GFM to contractor to support FY04-07 production.
  - Subjective upgrade to C-3. Unserviceable M865 do not impact training, nor readiness

Antitank

As of 31 Mar 2002

Category	Current			+6	+12	+18	+24
	S-	R-	C-	C-	C-	C-	C-
Antitank	2	2	2	2	2	3	3
Javelin	4	1	4	4	4	4	4
Dragon	1	4	4	4	4	4	4
TOW	1	2	2	2	2	2	3
Rockets	3	2	3	3	3	3	3

- ***Javelin***
  - The total Procurement Objective of 23,241 missiles to be delivered through FY09.
  - Units fielded to date have 78% of UBL; Expect 100% of UBL in 6 months
- ***Dragon (Condition Code N, War time use only)***
  - Dragon is prime shoulder-fired anti-tank weapon system until replaced by Javelin
- ***TOW***
  - Inventory includes TOW 2A assets against overall TOW 2B QWARRM07
  - TOW 2B Procurement Objective of 33,000 was less than QWARRM07
  - 46% of TOW 2A (SWA returns) are restricted to training use only
- ***Rockets***
  - Shortfall of new SMAW-D (Bunker Buster); Unserviceable AT-4.

Cannon Artillery

As of 31 Mar 2002

Category	Current			+6	+12	+18	+24
	S-	R-	C-	C-	C-	C-	C-
Cannon Arty	3	2	3	3	3	3	3
Lt How	4	4	4	4	4	4	4
155mm Proj	4	3	4	4	4	4	4
Prop Charges	3	1	3	3	3	3	3
Fuzes	1	1	1	1	1	1	1

- ***Light Howitzer (105mm)***
  - **DPICM M915 shortfall**
  - **Unserviceable HE M1, HE M760, HERA M913, and HC M84**
  - **Replacing prop charges / primers on HE M1**
- ***155mm Projectiles***
  - **HE M795, WP M110, RAAMS shortfall**
  - **Smoke Screening M825, DPICM M483A1 serviceability**
- ***Prop Charges – M203 red bag shortfall; Will be replaced by MACS***

GMLR Artillery

As of 31 Mar 2002

Category	Current			+6	+12	+18	+24
	S-	R-	C-	C-	C-	C-	C-
GMLR Arty	1	1	1	1	1	1	1
MLRS	1	2	2	2	2	2	2
ATACMS	1	1	1	1	1	1	1

- ***MLRS***
  - **Guided MLRS is presently not in production. Deliveries will begin in FY05.**
  - **Guided MLRS not rated.**
- ***ATACMS – M39A3 shortfall***
  - **M39A3 program is being updated to ATACMS Block II P3I. Deliveries from the P3I program will begin in FY06.**
  - **Block II not rated**

Air Defense

As of 31 Mar 2002

Category	Current			+6	+12	+18	+24
	S-	R-	C-	C-	C-	C-	C-
Air Defense	3	2	3	3	3	3	3
Stinger RMP Block 1	4	1	4	4	4	4	4
Stinger RMP	1	2	2	2	2	2	2
Patriot	3	2	3	3	3	3	3

- ***Stinger RMP Block 1***
  - **Block 1 modification program has not produced sufficient quantity to meet QWARRM07 requirements, due to funding constraints**
- ***Patriot***
  - **Reliability issues with PAC-2 / GEM caused decrease in number of serviceable missiles**
  - **PAC3 missiles FRP decision estimated by end of FY02.**

Medium Caliber

As of 31 Mar 2002

Category	Current			+6	+12	+18	+24
	S-	R-	C-	C-	C-	C-	C-
Medium Caliber	3	2	3	3	3	4	4
25mm	4	2	4	4	4	4	4
40mm f/ MK19	3	1	3	3	3	4	4
40mm f/ M203	1	4	4	4	4	4	4

- ***25mm – APFSDS-T M919 shortfall; Sub-item available (APDS-T M791)***
- ***40mm f/ MK19 Machine Gun – M430 HEDP at 78% fill***
- ***40mm f/ M203 Grenade Launcher***
  - **Recent suspension due to cartridge case extraction problem (parachute rounds); Wax coating being applied to bring back to serviceable condition**
  - **69% of M433 HEDP require screening for suspected projectile cracks**
  - **Projected shortfall of training ammo; Historical vs. projected**

Mortars

As of 31 Mar 2002

Category	Current			+6	+12	+18	+24
	S-	R-	C-	C-	C-	C-	C-
Mortars	2	1	2	2	2	2	2
60mm	1	1	1	1	1	1	1
81mm	1	1	1	1	1	1	2
120mm	4	1	4	4	4	4	4

- ***81mm – Overall rating of C-1, but single problem item***
  - **Unserviceable RP Smoke M819**
  - **Investigation underway; Fix not yet determined**
- ***120mm***
  - **M930 Illum shortfall**
  - **M934 HE w/ MOF shortfall**
  - **M933 HE w/PD recent suspension**

Other Support Items

As of 31 Mar 2002

Category	Current			+6	+12	+18	+24
	S-	R-	C-	C-	C-	C-	C-
Support Items	2	1	2	3	3	4	4
Smoke/Riot Ctl	1	1	1	2	2	4	4
Pyrotechnics	1	2	2	2	3	4	4
CAD/PAD	3	1	3	3	4	4	4
Grenades	4	1	4	4	4	4	4

- ***Smoke/Riot Control – Projected shortfalls; Historical vs. projected training***
- ***Pyrotechnics – Projected shortfalls; Historical vs. projected trng***
- ***CAD/PAD – M21 2 second delay cutter shortfall***
- ***Grenades***
  - **Shortfall of Offensive, Screening, and Smoke Grenades**
  - **Buying to historical training; Higher projected training**
  - **Reworking unserviceable M67 grenades over next 6 months**

Demolition Items

As of 31 Mar 2002

Category	Current			+6	+12	+18	+24
	S-	R-	C-	C-	C-	C-	C-
Demo Items	3	1	3	3	3	3	4
Demo Charges	2	2	2	2	3	3	4
Linear/Projected	1	1	1	1	1	1	1
Initiation Devices	2	1	2	2	2	2	2
Miscellaneous	4	1	4	4	4	4	4
MDI	4	1	4	4	4	4	4

- ***Demo Charges***
  - **C4 Blocks require extrusion**
  - **Projected shortfall of 40# Cratering and 15# Shaped Charges**
- ***Miscellaneous - Fighting Position Excavator, SLAM M4, and APOBS shortfall***
- ***Modern Demo Items (MDI) – Shortfall of several MDI items***

Mines - Countermines

As of 31 Mar 2002

Category	Current			+6	+12	+18	+24
	S-	R-	C-	C-	C-	C-	C-
Mine-Countermine	2	1	2	2	2	2	3
MICLIC	1	2	2	2	2	2	3
Modern Mines	4	1	4	4	4	4	4
AP Mines	1	2	2	2	2	2	2
AT Mines	Phase Out		6	6	6	6	6

- ***MICLIC - Projected shortfall of Rocket Motor MK22-4***
- ***Modern Mines***
  - **Hornet (WAM), M87A1 VOLCANO, and M131 MOPMS shortfall**
  - **Projected shortfall of M88 Practice VOLCANO**
- ***AT Mines – Being phased out***
  - **Available assets meet current CINC requirements**
  - **M15 heavy mines being used as demil donor charges**

C-Level Definitions

- ***C-1:*** ***Full mission capability; Unlimited flexibility***
- ***C-2:*** ***Mostly mission capable; Isolated decreases in flexibility***
- ***C-3:*** ***Can undertake many, but not all missions; Significant decrease in flexibility***
- ***C-4:*** ***Additional resources required***
- ***C-5:*** ***Activation, inactivation or conversion***
- ***C-6:*** ***One or more resource areas can not be rated***

From AR 220-1
Definitions adopted to fit munitions

On Hand (S-Ratings)

- ***Individual Item assessment***
  - On hand = Worldwide assets, less WRSA
  - Requirement = QWARRM 07 + Op Project or Training Pipeline (150 days)
  - On hand ÷ Requirement

Rating	On hand ÷ Reqmt
S-1	90 - 100%
S-2	80 – 89%
S-3	65 – 79%
S-4	0 – 64%

- ***Sub-family ratings***
  - Count # of S1, S2, S3, S4
  - If # of S1's >= 90%, S1
  - If # of S1's + S2's >= 85%, S2
  - If # of S1's + S2's + S3's >= 80%, S3
  - If # of S4's > 20%, S4

If any pacing item is lower, assign this lower rating to the sub-category

Serviceability (R-Ratings)

- ***Individual Item assessment***
  - Serviceable = CC A, B, C, and D
  - Serviceable ÷ Total assets
  - Include long supply
- ***Sub-family ratings***
  - Sum serviceable for all items
  - Sum total assets for all items
  - Sum serv ÷ Sum total = % for all

Rating	Serviceable ÷ Total
R-1	90 - 100%
R-2	70 – 89%
R-3	60 – 69%
R-4	0 – 59%

If any pacing item is lower, assign this lower rating to the sub-category

Composite (C-Ratings)

- ***Assign Composite ratings to Categories***
- ***Aggregate all S- and R- ratings using table***

Level	50% of Sub-categories	Avg of Sub-categories
1	1	1.54 or less
2	2 or better	1.55 to 2.44
3	3 or better	2.45 to 3.34
4	Cannot meet level 3	

- ***Assign C-rating***
  - **Start point is lower of S- and R- levels**
  - **Commander may adjust up or down; Subjective**

Pacing Items (AR 220-1)

- ***Key to a unit's capability***
- ***Central to a unit's ability to perform doctrinal mission***
- ***Identifies pacing items by unit type***

WEAPON SYSTEMS
Tanks
Howitzers
BFVs
APC's
Helicopters
Missile launchers

Ammunition Pacing Items

- ***Ctg, 5.56mm 4 Ball / 1 Tracer***
- ***Ctg, 7.62mm 4 Ball / 1 Tracer***
- ***Ctg, 25mm APFSDS-T M919***
- ***Ctg, 25mm TPDS-T M910***
- ***Ctg, 105mm HERA M913***
- ***Ctg, 105mm ICM M915***
- ***Ctg, 120mm APFSDS-T M829A2***
- ***Ctg, 120mm TPDSCS-T M865***
- ***Proj, 155mm HE M795***

Prime – Sub Relationships

PRIME	SUB
✓ 7.62mm M118 (AA11)	A136/A171
✓ 25mm AP M919 (A986)	25mm AP M791 (A974)
✓ 120mm AP M829A2 (C792)	M829A1 (C380)
✓ 120mm HEAT M830A1 (C791)	M830 (C787)
✓ 105mm ICM M915 (CA11)	M444 (C462)
✓ APOBS (MN79)	Bangalore (M028)

These prime items have significant performance improvement not matched by their respective substitute items.

DEFENCE R&D DÉFENSE

International Infantry & Joint Services Small Arms Systems Section Symposium, Exhibition & Firing Demonstration

Sheraton Atlantic City Convention Center Hotel

May 13 – 16, 2002

DEFENCE R&D DÉFENSE

Feasibility of an Eye-safe Laser-based Crosswind Velocity Measurement System for Sniper Rifles

Mr. L. Nappert[1], Dr. Y. Champagne[2], Mr. Y. Taillon[2]

[1]Defence R&D Canada - Valcartier

[2]INO

Defence Research and Development Canada | Recherche et développement pour la défense Canada

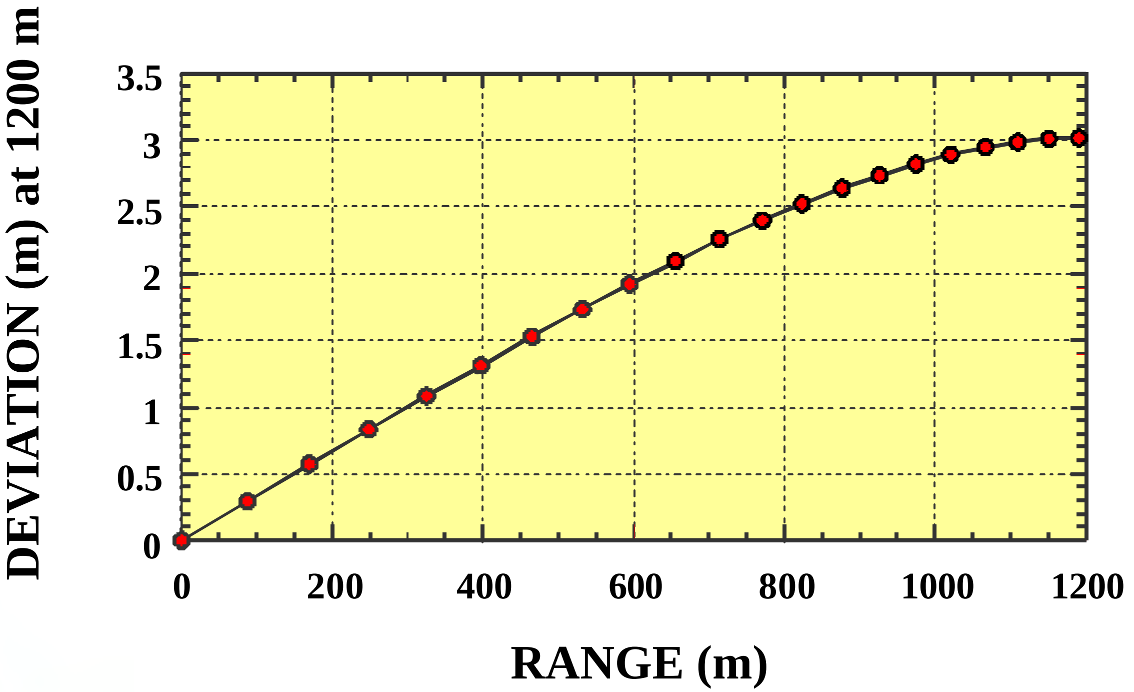
Canada

Content

- Crosswind influence
- Literature survey
- Coherent Doppler lidar system
- Performance analysis
- Conclusion

Crosswind Influence on a Bullet Trajectory

- Crosswind velocity = 4.47 m/s (10 mph)
- 0.338 Lapua Magnum bullet



Requirements for the Measurement System

- Range-resolved crosswind measurements
- Maximum range : 1500 m
- Range resolution : about 30 m
- Maximum crosswind velocity : 20 m/s (72 km/h)
- Velocity measurement accuracy : ± 1 m/s
- Measurement and computation time : ~ 1 s
- Eye-safe
- Autonomous
- Man portable

Crosswind Measurement Systems Analysed

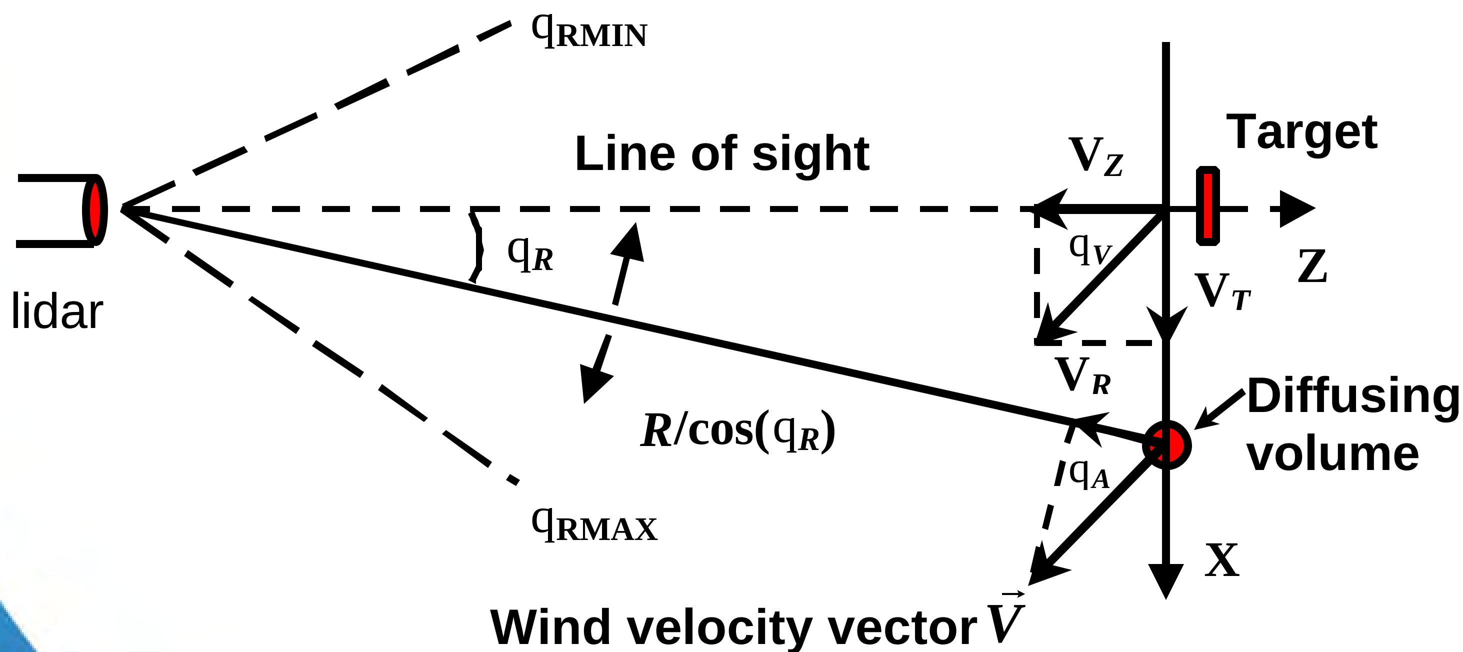
- Coherent Doppler lidar
- Direct-detection Doppler lidar
  - Edge-filter technique
  - Multiple-channel technique
- Temporal cross-correlation lidar
- Other systems based on optical scintillations

Crosswind Measurement Systems Analysed

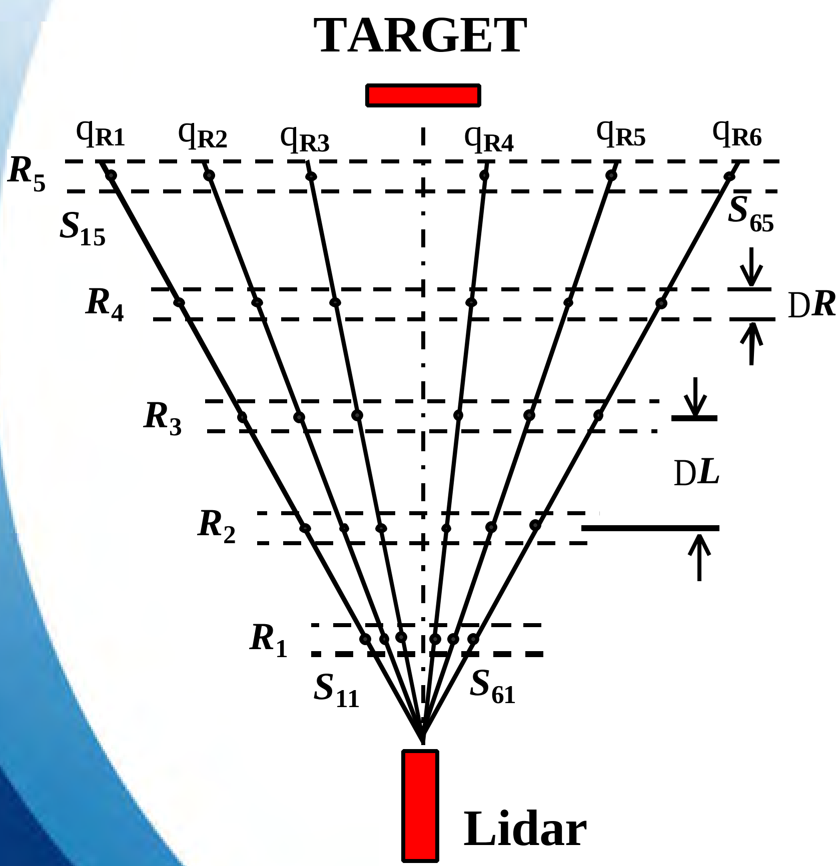
- Coherent Doppler lidar
- Direct-detection Doppler lidar
  - Edge-filter technique
  - Multiple-channel technique
- Temporal cross-correlation lidar
- Other systems based on optical scintillations

Crosswind Velocity Measurement: Basic Method

$$V_T = \frac{V_Z \cos(q_R) - V_R(q_R)}{\sin(q_R)}$$

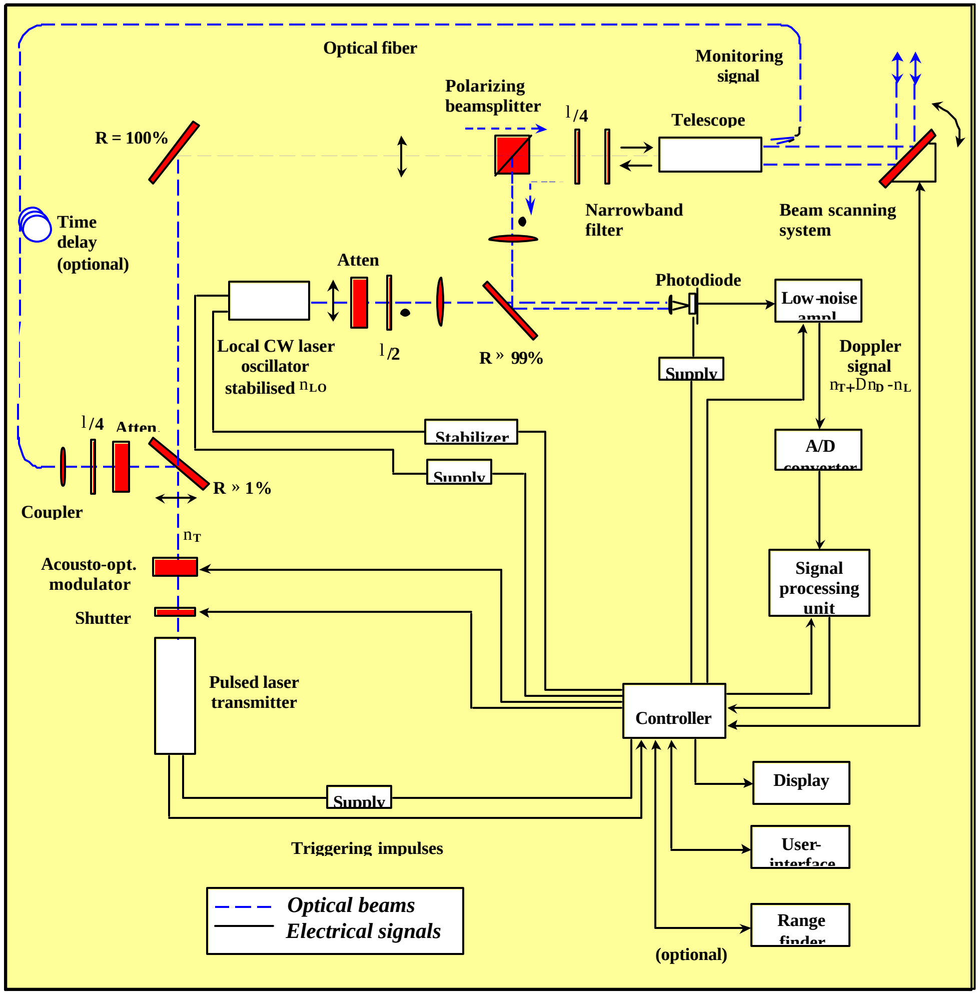


Crosswind Velocity Measurement: General Method

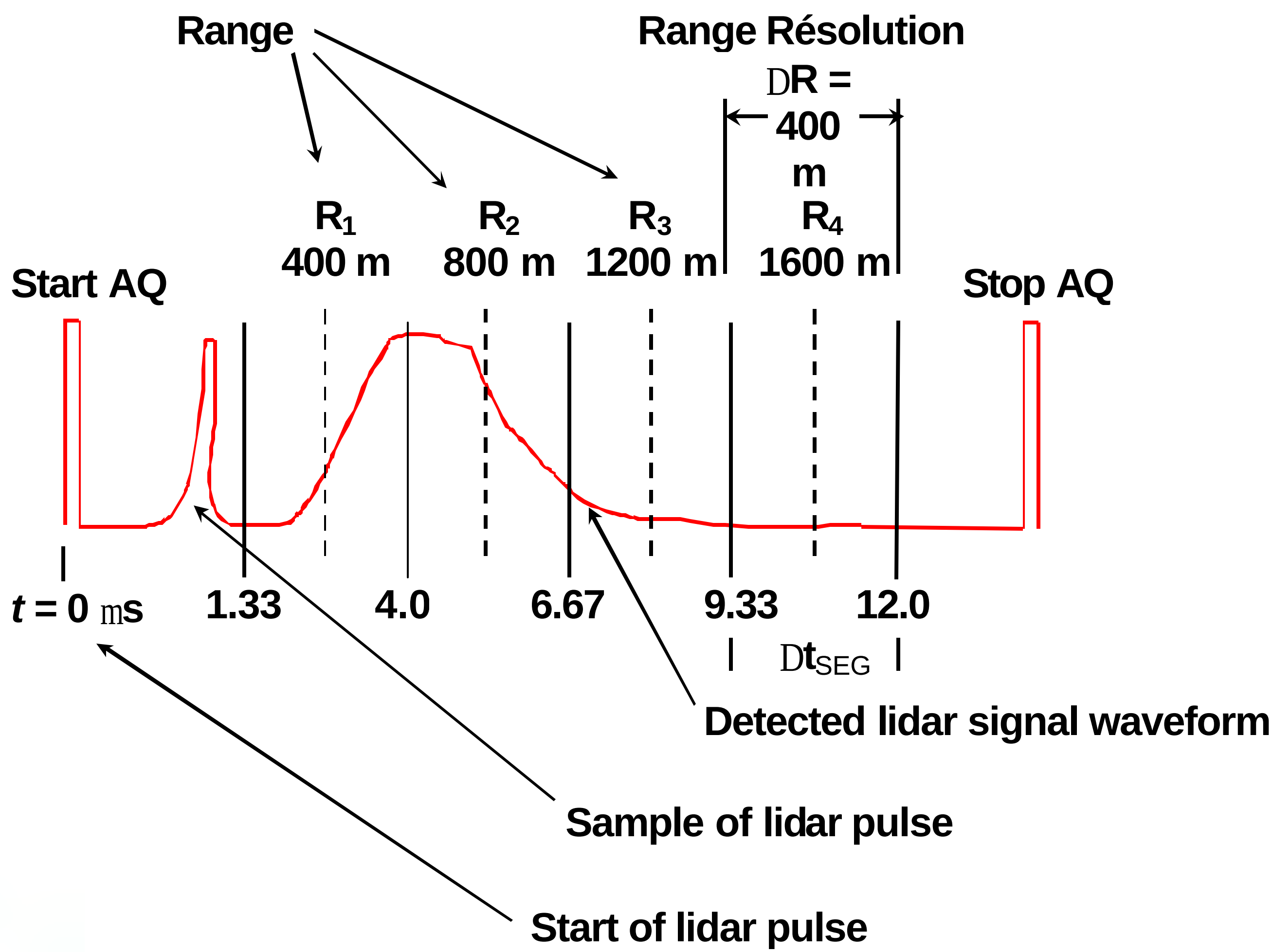


- At each range R_I:
  - Least-squares estimate of V_Z and V_T from the radial wind velocity measurements in each aiming direction
  - Variance calculation on the two estimated parameters

Assembly Diagram of a Coherent Doppler Lidar Crosswind Measurement System



Analysis of the Lidar Signal Waveform



Performance Equations

- Lidar equation

$$P_R(t) = P_E(t - 2R/c)\ \beta(\pi)\frac{A_e}{R^2}\left(\frac{c\tau_L}{2}\right)T_A(R)\,\eta_T\,\eta_R\,\eta_{SPEC}\,O_{FOV}(R)$$

- Signal to noise ratio

$$SNR = \frac{P_R\,\eta_Q\,\eta_{HET}}{h\nu\,B}$$

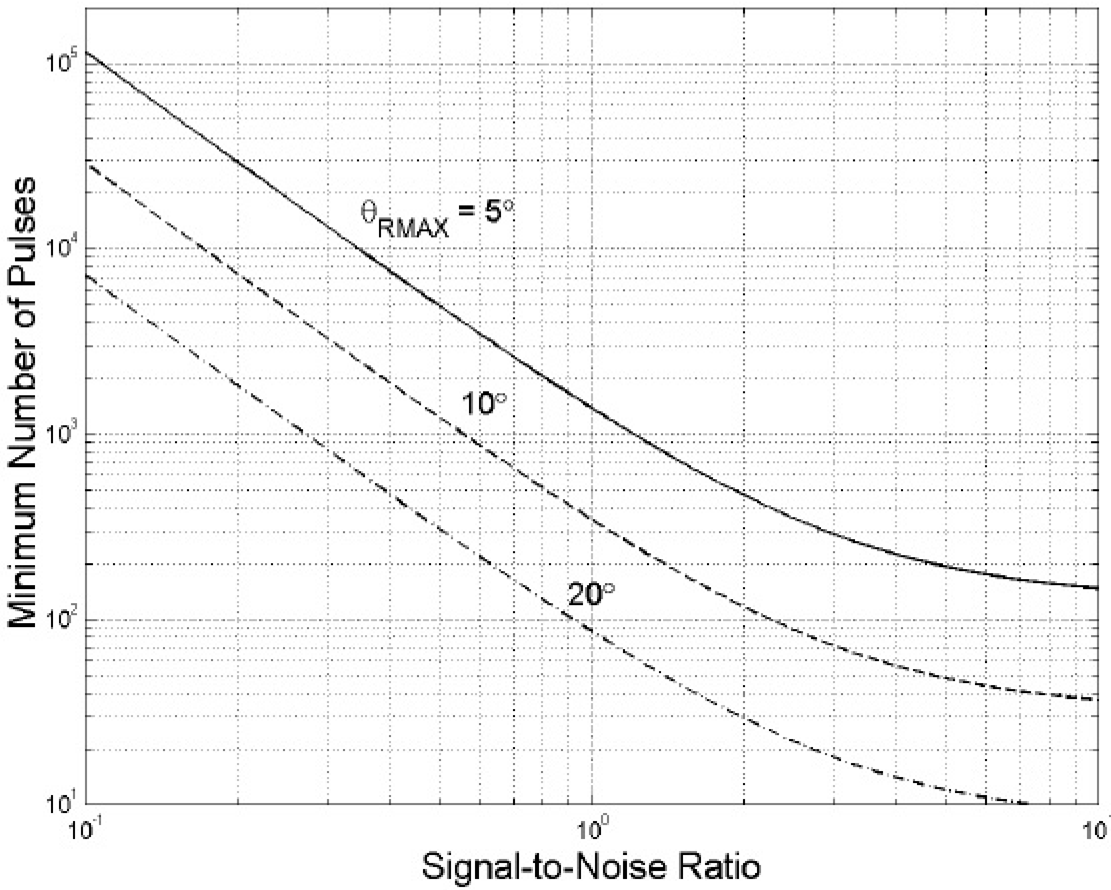
- Radial wind velocity measurement accuracy

$$\sigma_{VFFT}(\mathrm{m/s}) = \frac{\lambda}{2}\left(\frac{\phi}{N_P\tau_D}\right)^{1/2}\left[\frac{\Omega}{4\sqrt{\pi}} + \frac{2\Omega^2}{SNR} + \frac{1}{12SNR^2}\right]^{1/2}$$

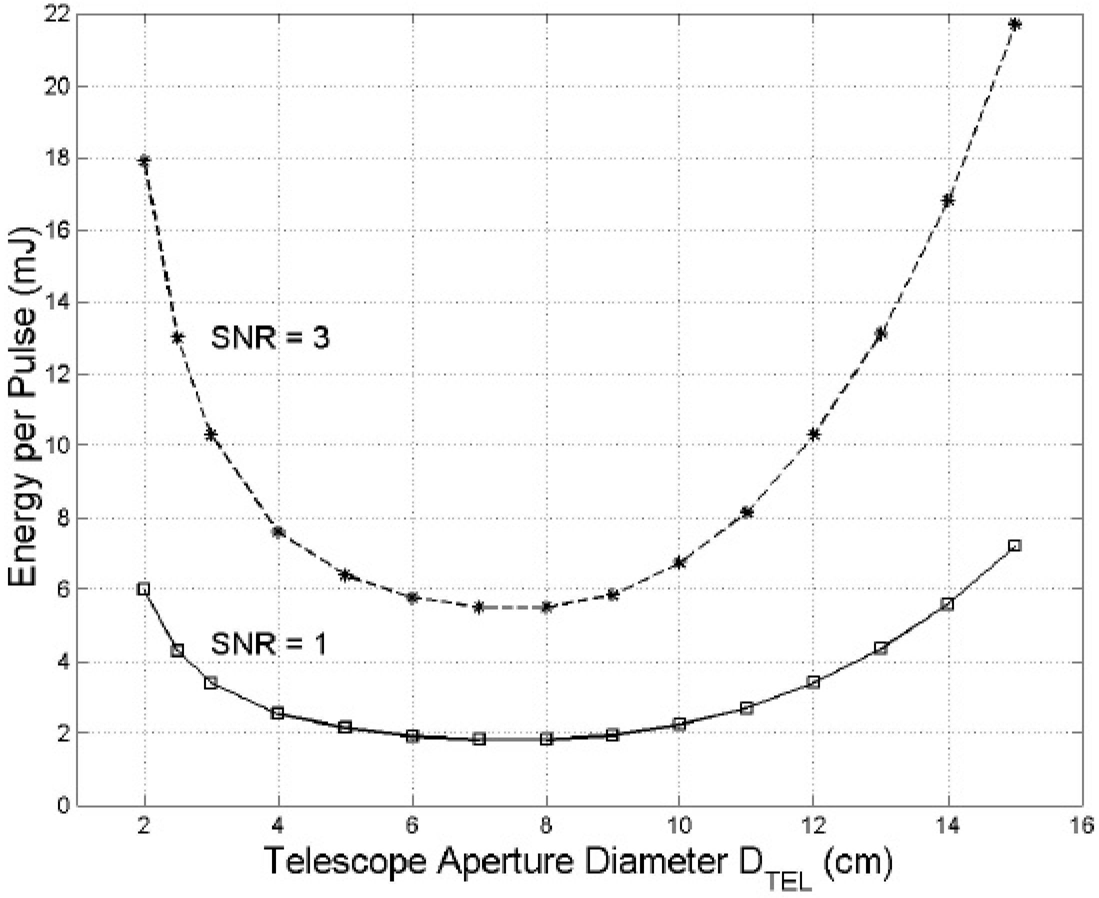
Critical Parameters

- Aiming angles q_{RMIN} and q_{RMAX} of the lidar with respect to the line of sight
- Number of laser pulses emitted in each aiming direction
- Lidar telescope aperture diameter
- Laser pulse energy

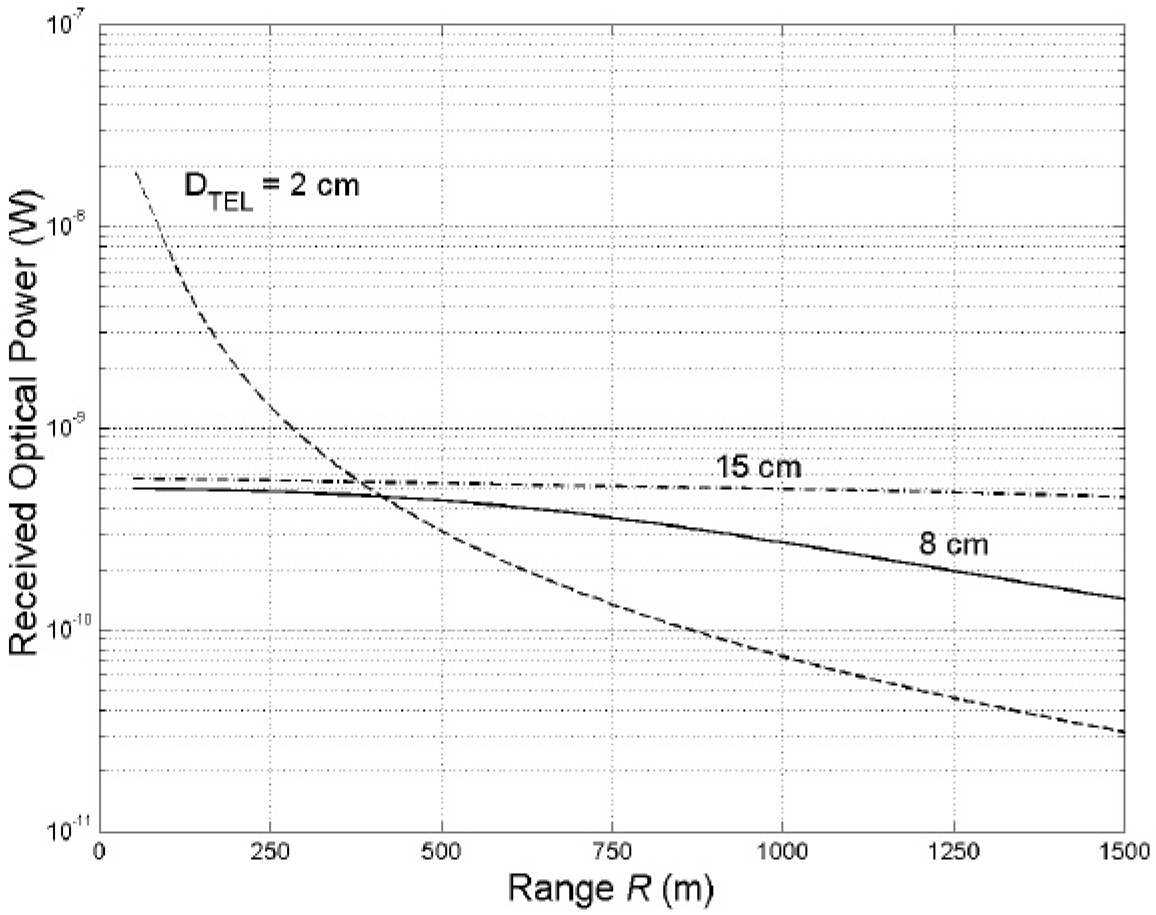
Required Number of Laser Pulses for Measuring the Crosswind Velocity within an Accuracy of ± 1 m/s



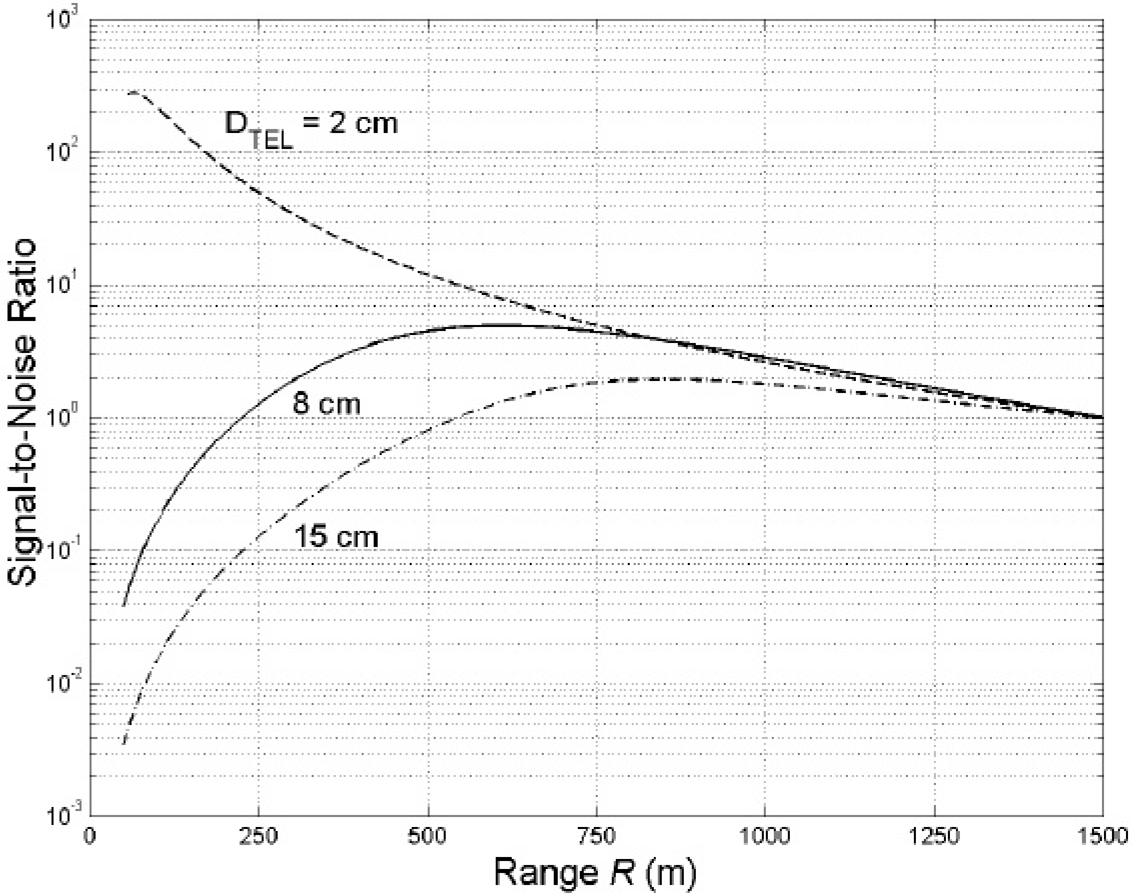
Required Laser Pulse Energy to Obtain a SNR of 1 and 3 at a Range of 1500 m



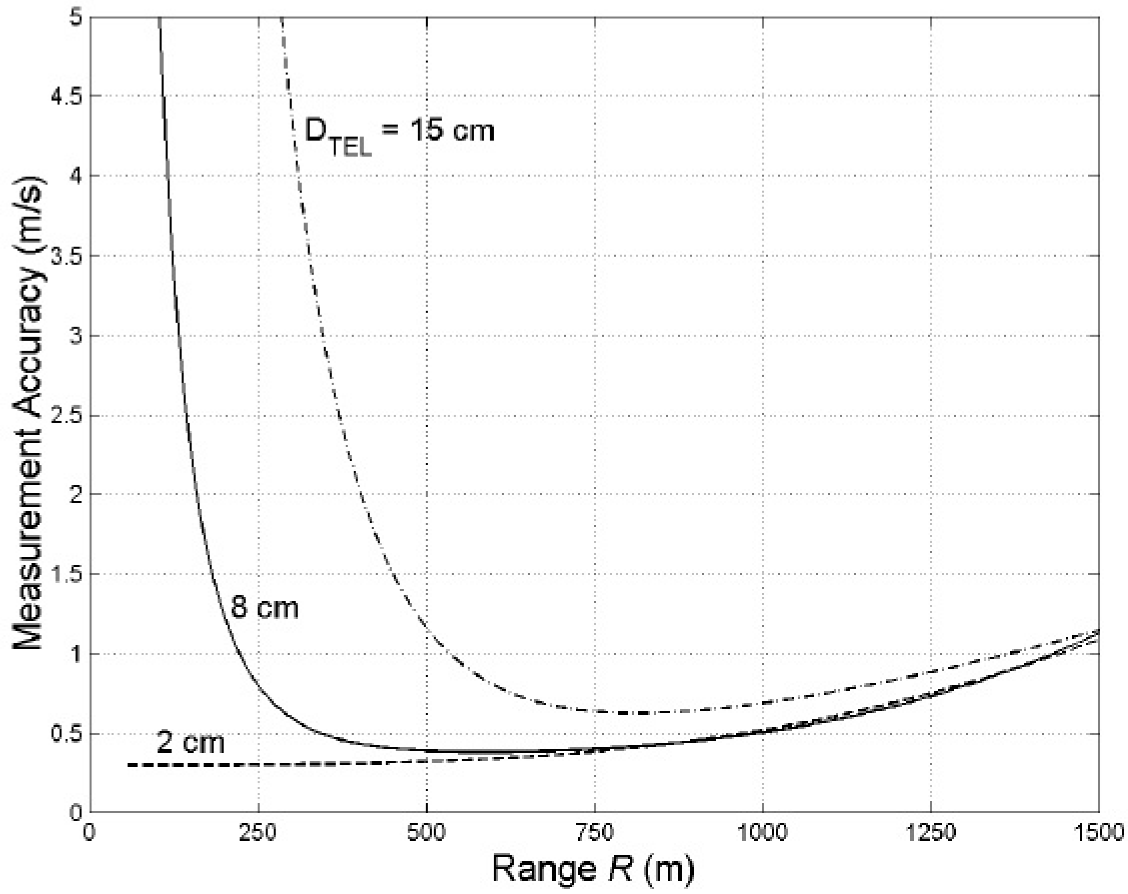
Received Optical Power at the Lidar Detector for Three Telescope Aperture Diameters



SNR for Three Telescope Aperture Diameters



Accuracy on Crosswind Velocity Measurement for Three Telescope Aperture Diameters



Conclusions

- Range-resolved crosswind velocity measurement is feasible, although much complex to perform
- Complex behaviour of the system performance as a function of range
- Eye-safe Tm:YAG laser (2.02 μm) emitting a few mJ of energy at a repetition rate of 100 Hz (telescope aperture diameter of about 8 cm)
- Typical measurement time from 5 to 10 s for seven aiming directions (± 20° with respect to the line of sight)

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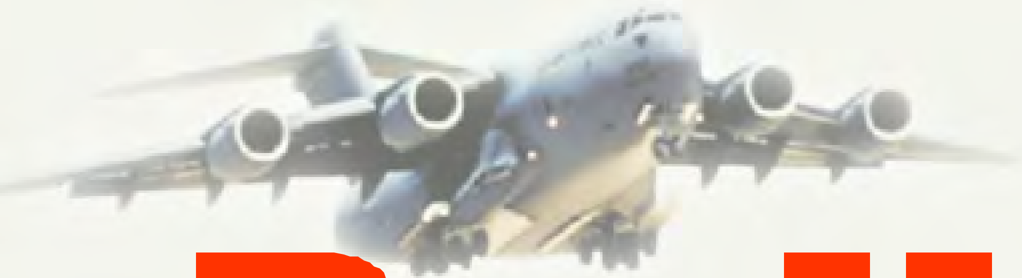

Raytheon

Miniaturization of IR & Small Arms Fire Control

2002 International Infantry &
JSSAP Section Symposium

Atlantic City

15 May 2002

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W000015-1 -06/04/2002


Raytheon Uncooled IR Products
...mature product base...market growth opportunities
Military
SMRTII
DVE
TWS
LRF/DCA
Pocket Sight
LPUIR
Ultra Light Sight
OCSW
Helmet Mounted FLIR
Crusader
1980s
Over a decade of technology leadership!
Police P200
300 Series
NightDriver (Cadillac)
NightDriver Display
PalmIR
PalmIR Pro
ProtectIR 4000B
2000 AS
ControlIR 2000B
Commercial
Raytheon


Heavy
Medium
Light
TWS MBS
Thermal Weapon Sights
Raytheon
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TWS Weapon-Fire Robustness - Been There!

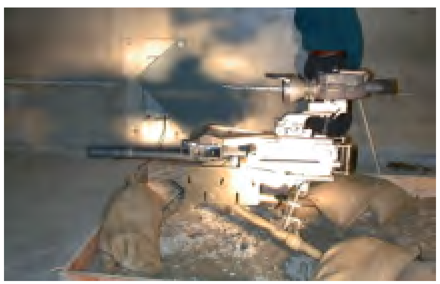
M2

M24

M240

M60

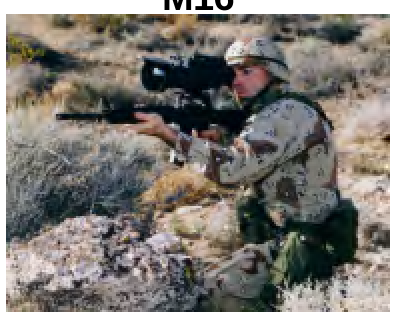
MK19



M249

M2

M16

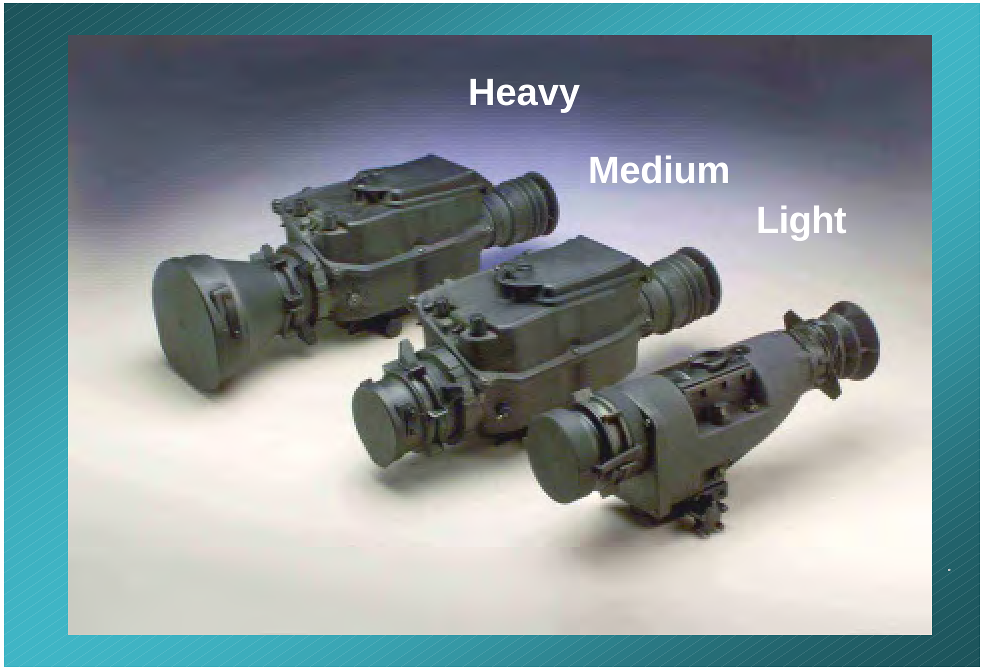


M4

Not Pictured:
M203, AT4

Raytheon
LIGHT FORCES

AN/PAS-13 Thermal Weapon Sight



Key Benefits:

- Enables soldiers to see in limited visibility situations, regardless of light conditions, including absolute darkness, bright sunlight, and through most battlefield obscurants at max effective ranges of weapon systems.
- Combat proven by US and allied armed forces
- Eyecup-activated stand-by mode
- Electronically generated reticles allow compatibility with a broad range of weapons

Applications:

- Handheld or weapon mounted up to .50 Caliber or grenade launchers
- Replaces TVS-5 and PVS-4 image intensifiers

System Description

Complete line of advanced infrared weapon sight with advanced features and rugged, lightweight, modular construction that compatible with a range of weapons.

Program Summary

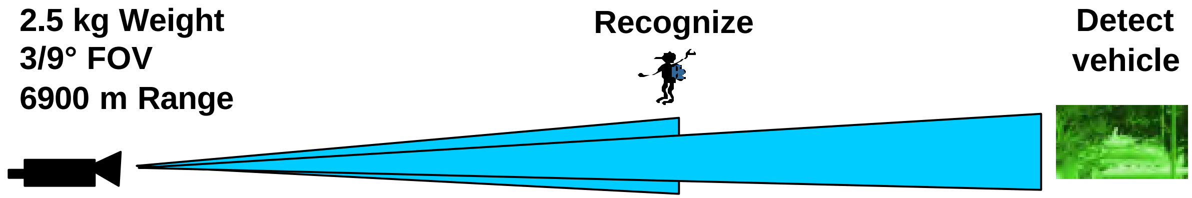
- Joint U.S. Army (lead) / USMC program
- Multi-year contract (3 yr base, 2 yr option)
- 1998-2003 period of performance
- Over 5000 TWSs delivered, >10,000 options remain

System Key Performance Parameters

HTWS

Used with M2, M4, MK19, M24, M82A2

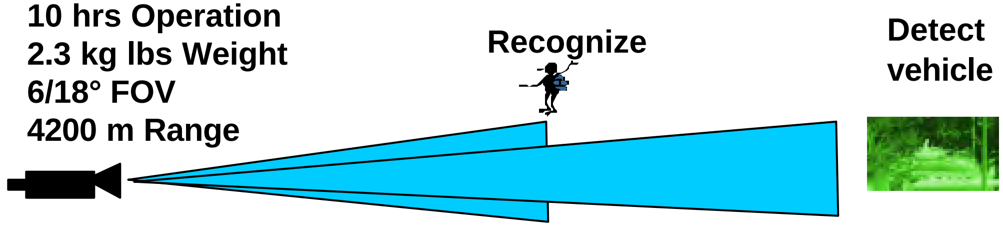
10 hrs Operation
2.5 kg Weight
3/9° FOV
6900 m Range



MTWS

Used with M4, M16, M60, M240, M249

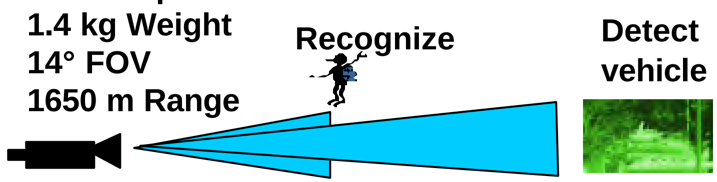
10 hrs Operation
2.3 kg lbs Weight
6/18° FOV
4200 m Range



LTWS

Used with M16, M4, M203, M136, AT4

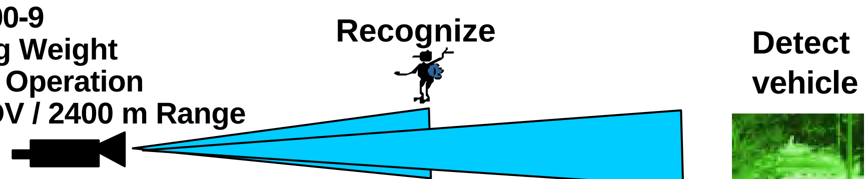
10 hrs Operation
1.4 kg Weight
14° FOV
1650 m Range



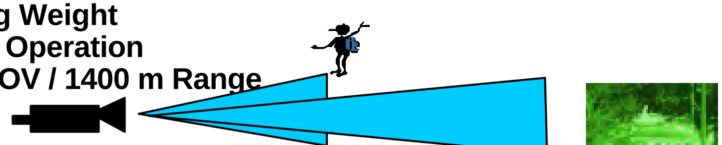
W1000

Various Weapons

W1000-9
1.7 kg Weight
8 hrs Operation
9° FOV / 2400 m Range



W1000-15
1.6 kg Weight
8 hrs Operation
15° FOV / 1400 m Range



Heavy & Medium Thermal Weapon Sights

HTWS

- **Det/Rec of Man: 1650 NFOV**
- **WFOV: 9^{O} az x 3.6^{O} el**
- **NFOV: 3^{O} az x 1.8^{O} el**
- **Mag: W = 3.3X, N = 10X**
- **Weight: 5.38 lbs w/o Battery**

MTWS

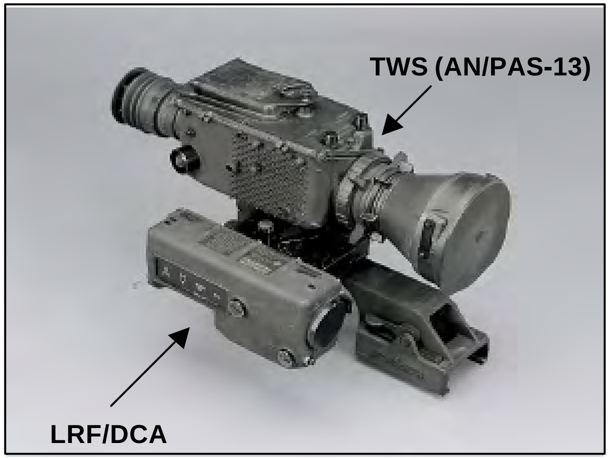
- **Det/Rec of Man: 2200 NFOV**
- **WFOV: 18^{O} az x 10.8^{O} el**
- **NFOV: 6^{O} az x 5.4^{O} el**
- **Mag: W = 1.66X, N = 5X**
- **Weight: 4.38 lbs w/o Battery**

The AN/PAS TWS is subject to the United States Arms Export Control Act (AECA) and the International Traffic in Arms Regulations (ITAR). Export requires license approval from the US State Dept./Office of Defense Trade Controls. Cleared for Public Release August 2000 by SAPA/ and NV-RSTA.

TWS Modular Ballistic Solution (TWS MBS)

Raytheon

Specification	TWS	LRF/DCA
Length	40 cm (15.8 in)	21.6 cm (8.5 in)
Width	16 cm (6.3 in)	8.3 cm (3.25 in)
Height	16 cm (6.3 in)	10.16 cm (4.0 in)
Weight w/ battery	2.3 kg (5.0 lb)	0.8 kg (1.8 lb)
Operating Temperature	-37º C to +49º C	-32º C to +49º C
Storage Temperature	-46º C to +71º C	-46º C to +71º C
Time to operation	Less than 120 seconds	Instantaneous
Power Requirements	6 volt BA-5847 or BB-2847	3 volt BA-5123/U or DL123A or commercial equivalent (2 ea)
Mounting	MIL-STD-1913 Rail System	MIL-STD-1913 Rail System
Remote Operation/ Data Transfer	RS-170	RS-232
Mechanical Shock	Withstands primary weapon fire shock (Mk19, M2, and other crew served weapons). Remains aligned after weapons fire.	
Range Output	First or last target ranges are displayed on the TWS within 0.2 seconds after valid return. User selectable. Selected range used for the partial ballistic solution.	
Recognize Man	2.8km	N/A
Detect Vehicle	6.9 km	N/A
Image Polarity	White hot/Black hot	N/A
Detector	40 x 16 scanning FPA, 3-5µm	N/A
Cooling	6-stage thermoelectric cooler	N/A
Detection Range	N/A	99% P(d) at >2500m, 2.3m x 2.3m 10% reflectivity target, 7km visibility
Range Accuracy	N/A	+/- 5 m (3 sigma)
Laser Fire	N/A	<0.10 sec. w/in receipt of command
Substained Fire	N/A	60 pulses/minute continuous
Eyesafety	N/A	Class I per ANSI-Z136-1-1993
False Return Rate	N/A	<1%
Wavelength	N/A	1.533 micron
Beam Divergence	N/A	86% within 0.8mr
Pulse Width	N/A	15-20 ns Full Width Half Maximum



The Thermal Weapon Sight Modular Ballistic Solution (TWS MBS) system combines a fully qualified and fielded Thermal Weapon Sight (AN/PAS-13) cabled to the Manportable Laser Rangfinder/Digital Compass Assembly (LRF/DCA) to provide a disturbed reticle for accurate engagements to the outer effective ranges of the MK19 and M2 platforms (greater than 2km). Both the TWS and LRF/DCA have been tested extensively on the MK19, M2, and other crew served weapons. The TWS MBS can be remotely operated and viewed through a common RS-170 interface port. The interface bracket for both platforms use the standard issue Army brackets with an additional rail grabber for mounting the LRF.

This product is regulated by the United States Arms Export Control Act (AECA) and the International Traffic in Arms Regulations (ITAR) 22 C.F.R. Parts 120-130. Cleared for Public Release January 2001 by SAPA/NV-RSTA.

Light Thermal Weapon Sight (LTWS)

Raytheon

Weight (lb)	1.4 kg (3.0 lb) w/ battery
Detection Range	
Human	550 m
Vehicle	1650 m
Field of View	15 deg az x 11.3° el
Operating Temperature	-37° C to +49° C
Maintenance	Cleaning only
Video Output	RS-170/NTSC
Power Requirements	Commercial AA Batteries or auxiliary power (via connector for DC sources)
Mission Operation Life	5 hrs on commercial AA alkaline or lithium batteries
Detector	320 x 240 staring (76,800 pixels) FPA
Spectral Band	8-12 µm (longwave infrared)
Cooling	Uncooled ferroelectric
Weapon Compatibility	M16, M4 - Up to fully automatic 5.56mm CAL
Mounting	Picatinny MIL-1913 or NATO/STANAG

The Light Thermal Weapon Sight (LTWS) is one of the lightest thermal sights available to today's warfighter. The LTWS is based on the combat-proven technology that drives Raytheon's highly fielded line of thermal imaging products. Features of the LTWS are a 2-to-1 electronic zoom, Liquid Crystal Display (LCD), and an eyecup activated stand-by mode for power conservation. The use of the LTWS cannot be detected since it emits no light or RF energy, and it can be used round the clock as ambient light is not required for its operation. Its light weight and compact design make it ideal for use as a hand-held imager and as a rifle mounted sight.

W1000 Uncooled Thermal Weapon Sight

Key Benefits:
- Detects targets in limited visibility situations, regardless of light conditions, including absolute darkness, bright sunlight, and through most battlefield obscurants
- Combat proven by US and allied armed forces
- Undetectable since IR light and illuminators are not required for use
- Electronically generated reticles allow compatibility with a broad range of weapons

Applications:
- Hand-held thermal imager
- Rifle-mounted sight adaptable to a broad range of weapons, up to 7.62mm (.308cal) guns.

System Description

Lightweight thermal weapon sight that employs Raytheon's proven uncooled focal plane array technology. Rugged, durable construction is combined with advanced features and extended battery life to fit any mission profile.

AN/VAS-5 Driver's Vision Enhancer (DVE)

Key Benefits:

- Improved **24 hour driving capability** to wheeled and tracked vehicles.
- Penetrate smoke, fog and other battlefield obscurants.
- Enhances mobility and maintains OPTEMP.

System Description:

Infrared sensor module & flat panel display with operator controls (B-Kit) and vehicle unique mounting (A-Kit).

Program Status

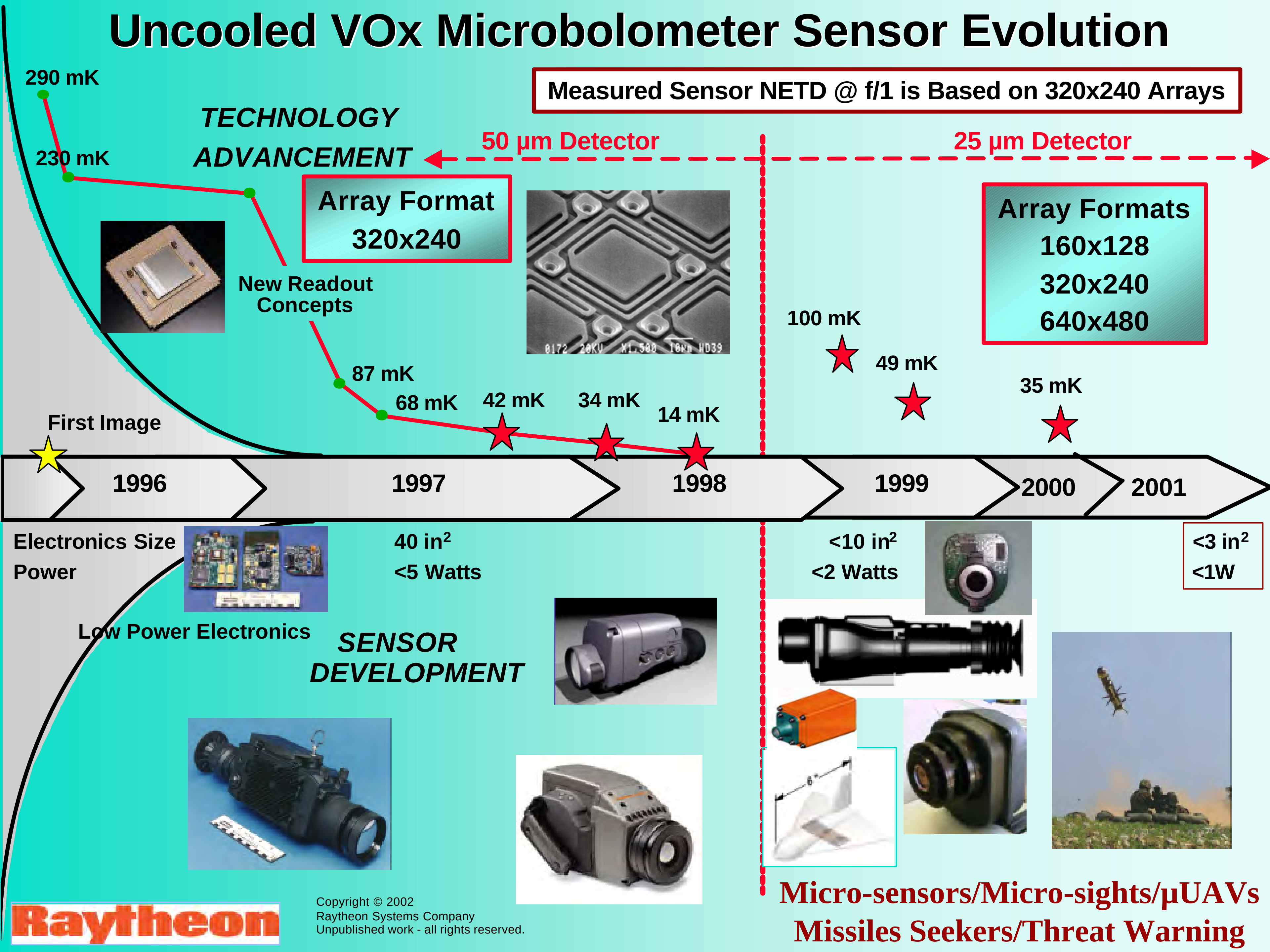
- US Army fielding began in 1998 w/ Bradley, M113
- USMC fielding began in 2Q01 w/ M1, LAV, AAV
- US Army plans to field DVE to all vehicles in IBCT
- USCG plans to field DVE for small & medium security/rescue boats beginning 3Q02
- Delivered 1400 systems
- Backlog, 3000 systems

Low Cost Microsensors
640x480 Dual-FOV Camera

The Next Generation of Thermal Weapon Sights

Raytheon

NVESD


Uncooled VOx Microbolometer Sensor Evolution
Measured Sensor NETD @ f/1 is Based on 320x240 Arrays
TECHNOLOGY ADVANCEMENT
50 µm Detector
25 µm Detector
290 mK
230 mK
Array Format
320x240
New Readout Concepts
87 mK
68 mK
42 mK
34 mK
14 mK
100 mK
49 mK
35 mK
Array Formats
160x128
320x240
640x480
First Image
1996
1997
1998
1999
2000
2001
Electronics Size
Power
40 in²
<5 Watts
<10 in²
<2 Watts
<3 in²
<1W
Low Power Electronics
SENSOR DEVELOPMENT
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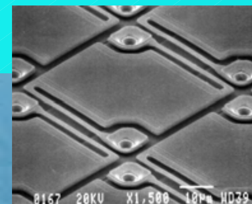
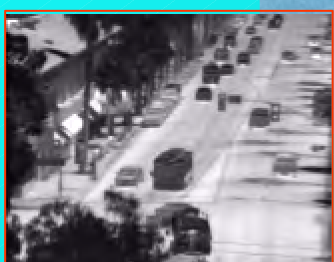
Raytheon
Micro-sensors/Micro-sights/µUAVs
Missiles Seekers/Threat Warning

Small Pixel Detector Arrays Miniaturize Modern InfraRed Sensors

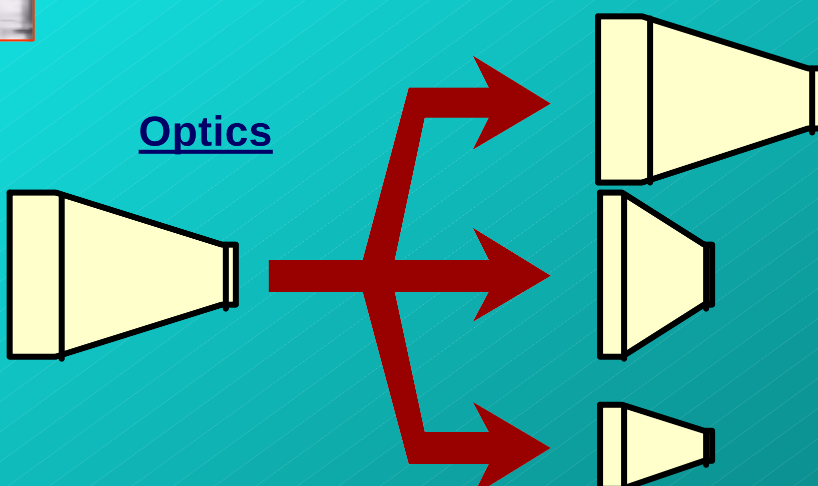




50 mm Sensors

25 mm Sensors

Optics



Expanded Trade Space

2× improvement in IFOV @ constant f/#, aperture

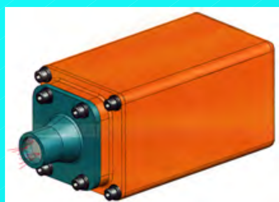
~2× improvement in NETD @ constant aperture, IFOV

~8× reduction in volume @ constant f/#, IFOV

Raytheon

Small Pixel Enables Wide Range of Applications

160 x 128



Microsensors

320 x 240

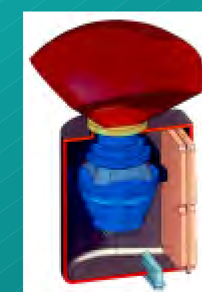
Man-Portable

μ-UAV

640 x 480

Long-Range Surveillance & Targeting

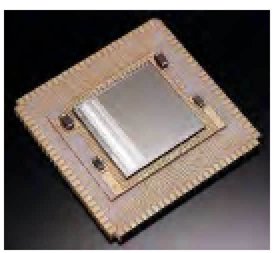
Megapixel



Ultra-WFOV Imaging

Missiles

Uncooled VOx 320 x 240
25 mm Pixel Compact Camera



25 mm Pixel 320x240 Camera
60 mK NEDT

- **1.8 watt Sensor Power**
- **August 2000 Camera**

DUAP Sights

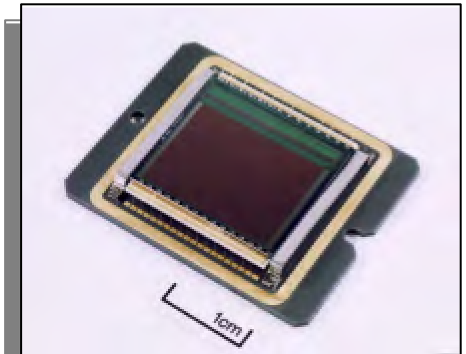
SB-246 VOx Delivers State-of-Art 640x480 Uncooled Imagery

- ✓ TV equivalent resolution of 640 x 480
- ✓ No cryogenic cooler

- ✓ Smallest detector pitch in industry - 25 um
- ✓ Highest Sensitivity
- ✓ Lowest Power - 2.8 Watts
- ✓ Battery Operated

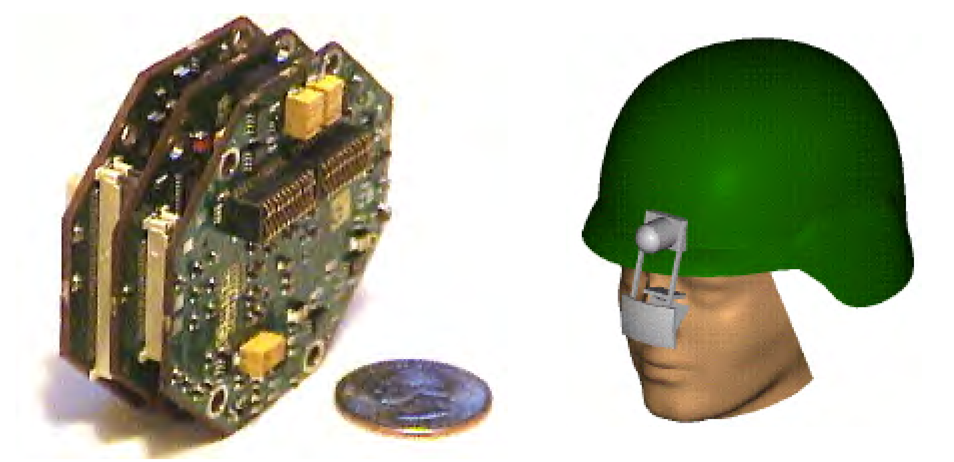
4.6º x 6.1º FOV Images

640x480 Sensor Engine Meets Aggressive Goals



640x480 25 mm Detector

- Detector fits into 320x240 packaging
- Sufficient room for indium ring for wafer level packaging.

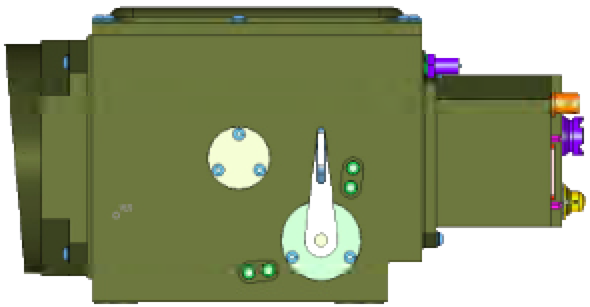


2.5"x2.5"x1" Compact Sensor Engine
< 145 Gram Sensor Engine Weight

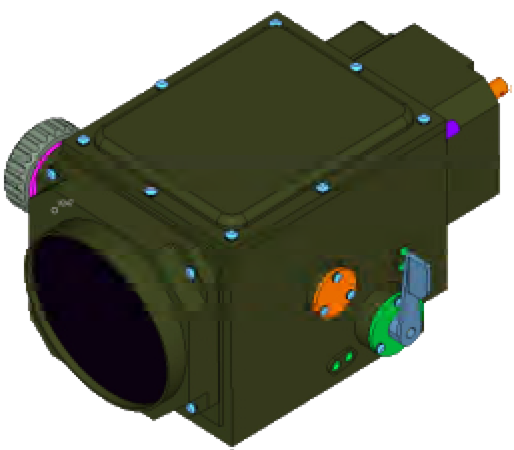
2.8 Watt Typical Operational Power

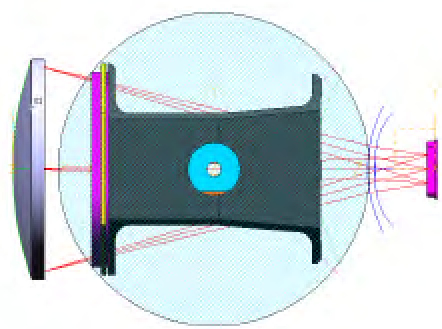
Dramatically reduced uncooled sensor cost, power, size & weight

640x480 Uncooled Camera



Dual Field-of-View
3.6” Aperture Optics
640 x 480, 25 mm pixel

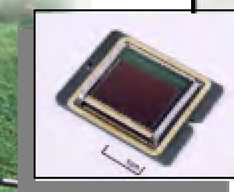




Compact Optical Form

OVERALL SIZE: 10.9 L x 7.7 W x 5.4 H
MAIN HOUSING: 10.2 L x 4.9 W x 5.4 H

Low Cost MicroSensors Program Summary



- **Raytheon 25 um pixel uncooled technology providing light-weight, compact, low power, affordable solutions**
- **640x480 imagery ushers in new uncooled era**

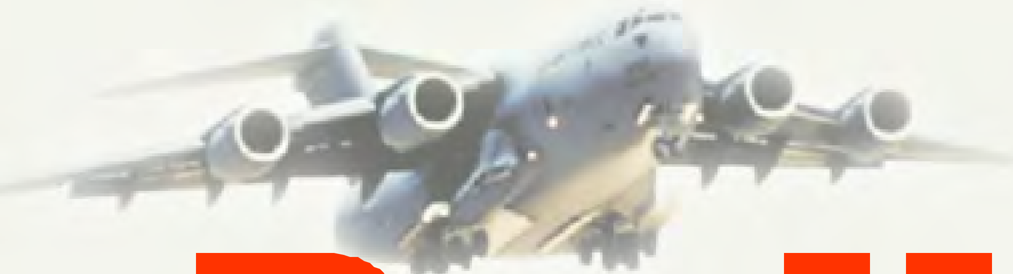
Raytheon

OCSW ATD TA/FCS
- Status -

Full Solution Fire Control

- ✓ 2.2 km Range Performance
- ✓ < ±1 meter Laser Rangefinder
- ✓ Ballistic Processor
- ✓ Single Reticle
- ✓ Fuze Setter
- ✓ Digital Compass
- ✓ Cant & Elevation Sensors
- ✓ Embedded Training
- ✓ Tactical Engagement Simulation
- ✓ Combat ID
- ✓ Thermal Sensor Interface
- ✓ Direct View Optics 5x9.5° FOV
- ✓ Land Warrior I/O
- ✓ NIR & Visible Laser Pointers
- ✓ Laser Steering
- ✓ Motion Tracker
- ✓ Atmospheric Temp. & Pressure
- ✓ Moving Targets

Demonstrated on Weapon
> 2000 Live Rounds Failure Free



Raytheon

Miniaturization of IR & Small Arms Fire Control

2002 International Infantry & JSSAP Section Symposium

Atlantic City

15 May 2002

Chuck Nourrcier
Raytheon Electronic Systems
cnourrcier@raytheon.com
972 344 4857

TACOM

Lethality, Survivability, Mobility and
Sustainment for America's Army

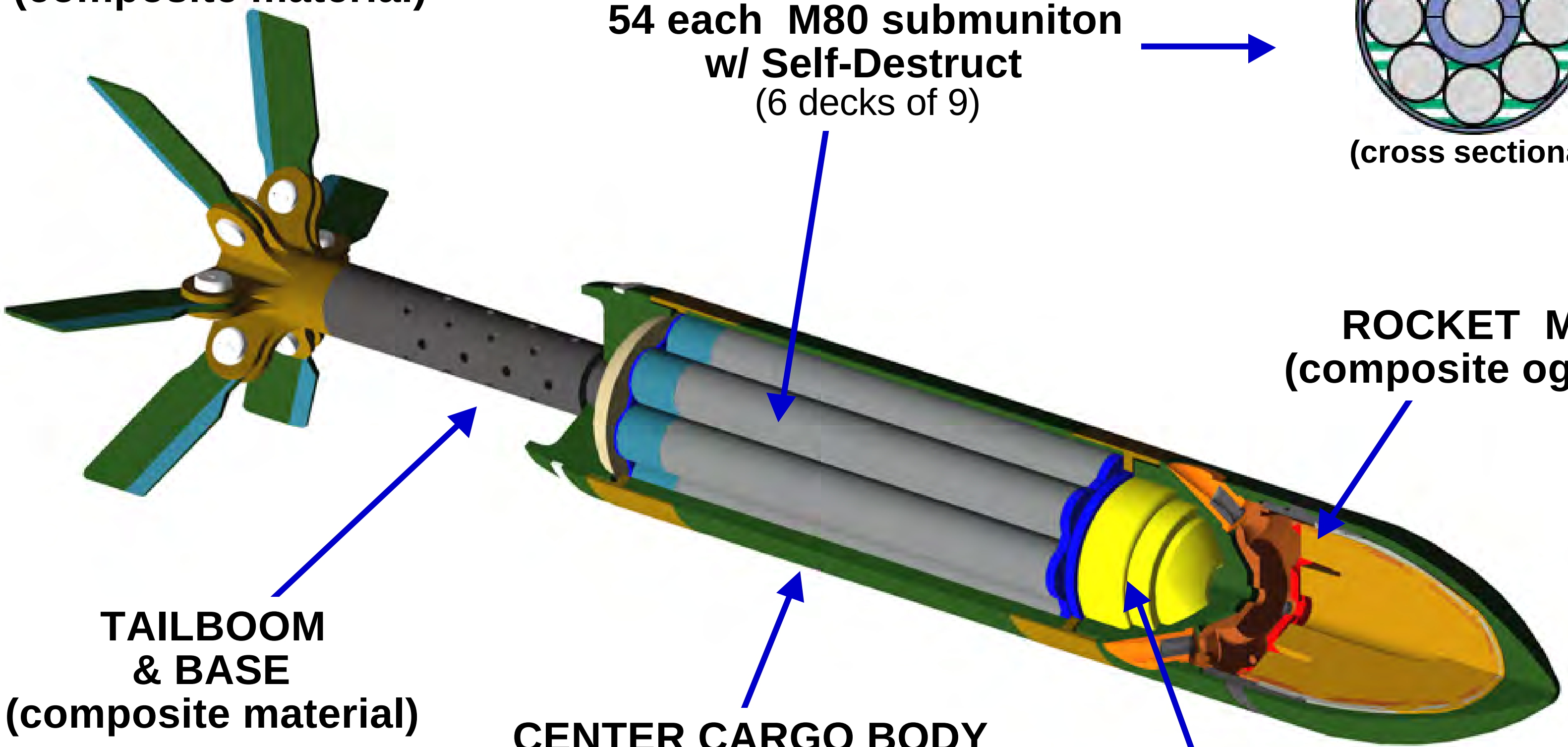
2002 International Infantry & Small Arms Symposium, Exhibition & Firing Demonstration

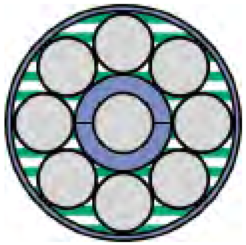
XM984 120mm Mortar Cartridge Extended Range DPICM

May 14, 2002

Presented by: Daniel Pascua
US Army TACOM-ARDEC
Picatinny Arsenal, NJ 07806-5000
phone: 973-724-4548
e-mail: dpascua@pica.army.mil

XM984 ER-DPICM 120mm Mortar Cartridge

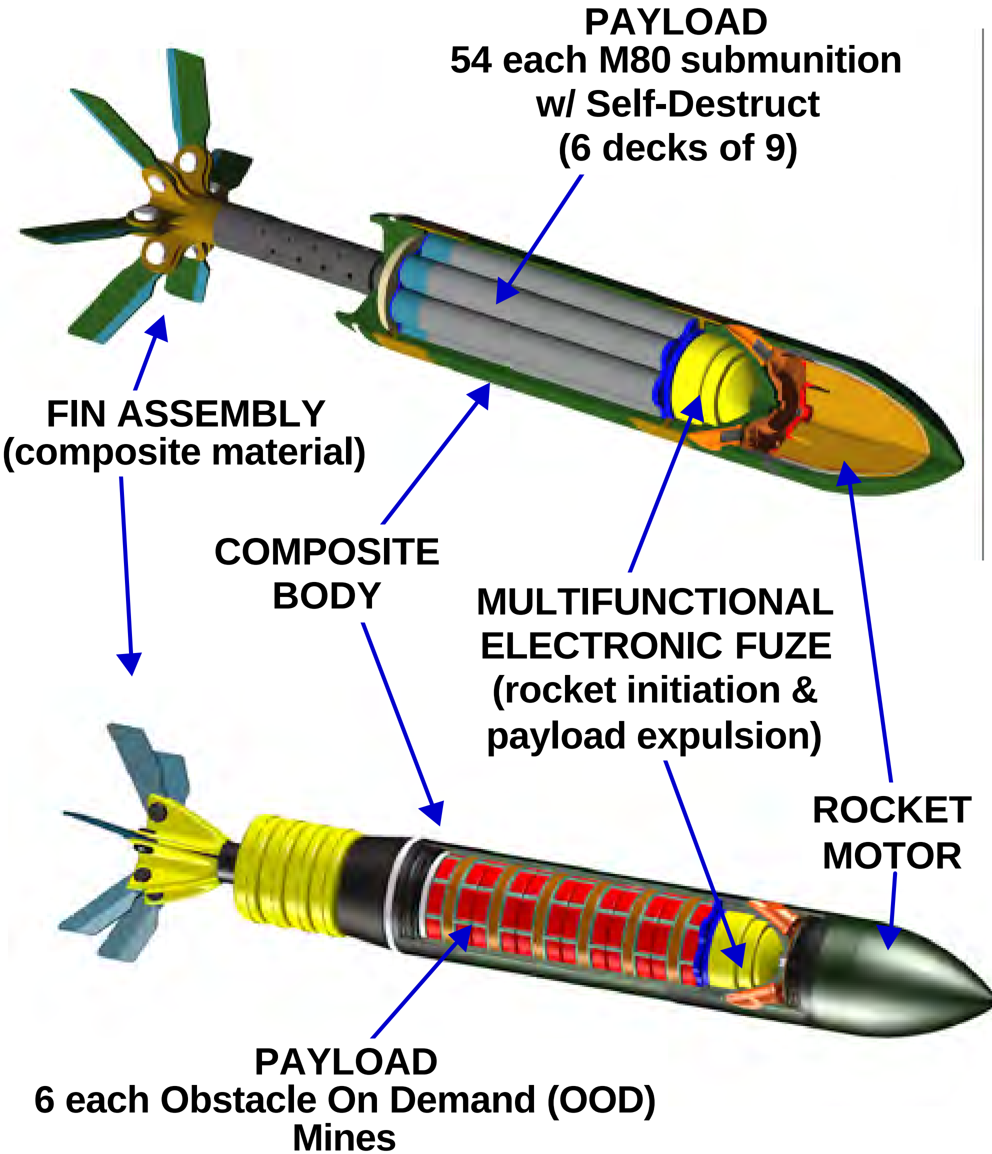




(cross sectional)

Total Weight = 33 lbs

Extended Range 120mm Cargo Munition



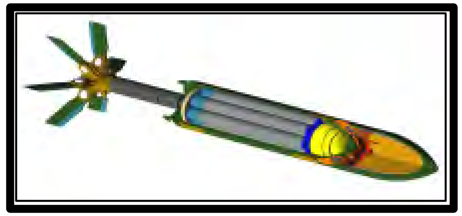
Description

- 120mm cargo carrying round
- Rocket Assist for Extended Range
  - 11 km range -- 52% Increase Vs Conventional
  - 233% Area Coverage Increase Vs Conventional
- Enhanced Lethality
  - 54 M80 DPICM Submunitions with Self Destruct Fuze
  - 82% Greater Anti-personnel Effectiveness
- Multifunction Electronic Fuzing
- Generic Configuration
  - Accommodates a Wide Variety of Payloads, include Unitary, Smoke, Illumination, SFM, Thermobaric, Mines and Non-Lethal.

XM984 ER-DPICM 120mm Mortar Cartridge

STO Goal: Develop and demonstrate a 120mm DPICM carrying Mortar Cartridge having significantly greater range capability and lethal effectiveness than currently attained

Capability	Current Capability standard 120mm	USAIC Req'mt XM 984
Weight	30 lbs	33 lbs
Max Range	7.2 km	10 - 12 km



Live-Fire Structural Integrity Test

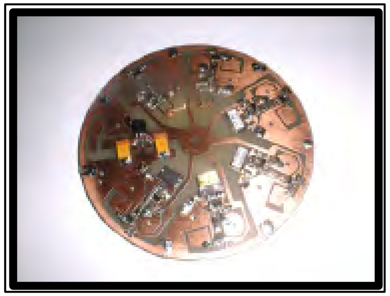
Rocket Propulsion of XM984 in Flight

STO Accomplishments:

- **Successful range flight demo test confirming rocket motor and exterior ballistic performance to 8.7 km (23% greater than US fielded mortar).**
- **Critical composite airframe components of cargo body and rocket motor ogive survived high-G launch live fire.**
- **Rocket motor interior ballistic characterization data to achieve extended range. Six-degree of freedom (6 DOF) modeling data predicts an 12 km range with time of flight of 60 sec.**
- **On-board VMRI sensors to measure muzzle velocity during high-G environment in air gun.**

STO Ended in FY01: TRL 5

Test Hardware

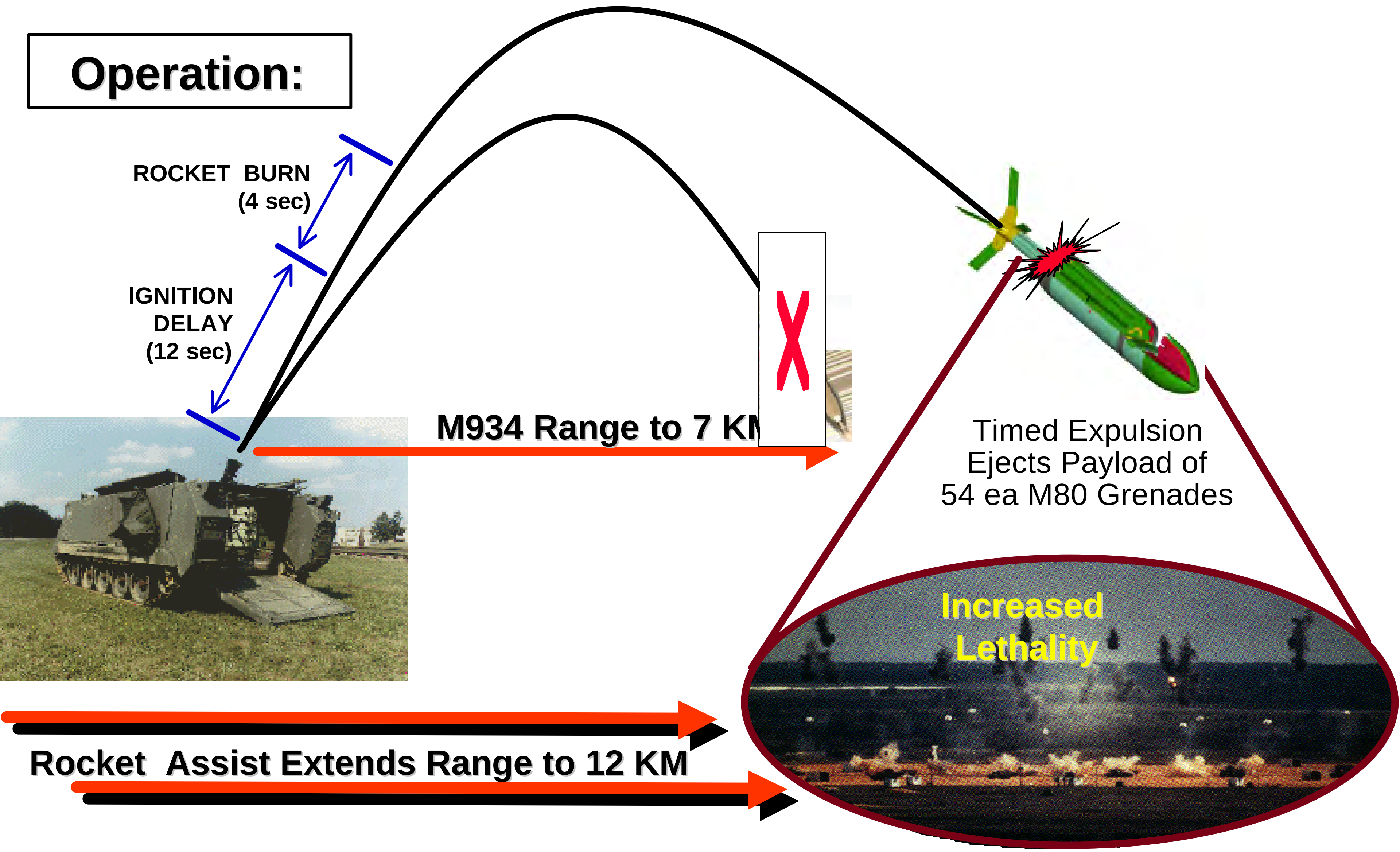


VMRI Crystal Test Fixture

Characteristics

• Range	12 km
• Weight	33 lbs
• Length	37 inches
• Payload	54 each M80 grenades
• Body Material	lightweight composites
• Rocket Motor	
- Material	resin transfer composite
- Grain Weight	3.86 lbm.

XM984 ER-DPICM 120mm Mortar Cartridge

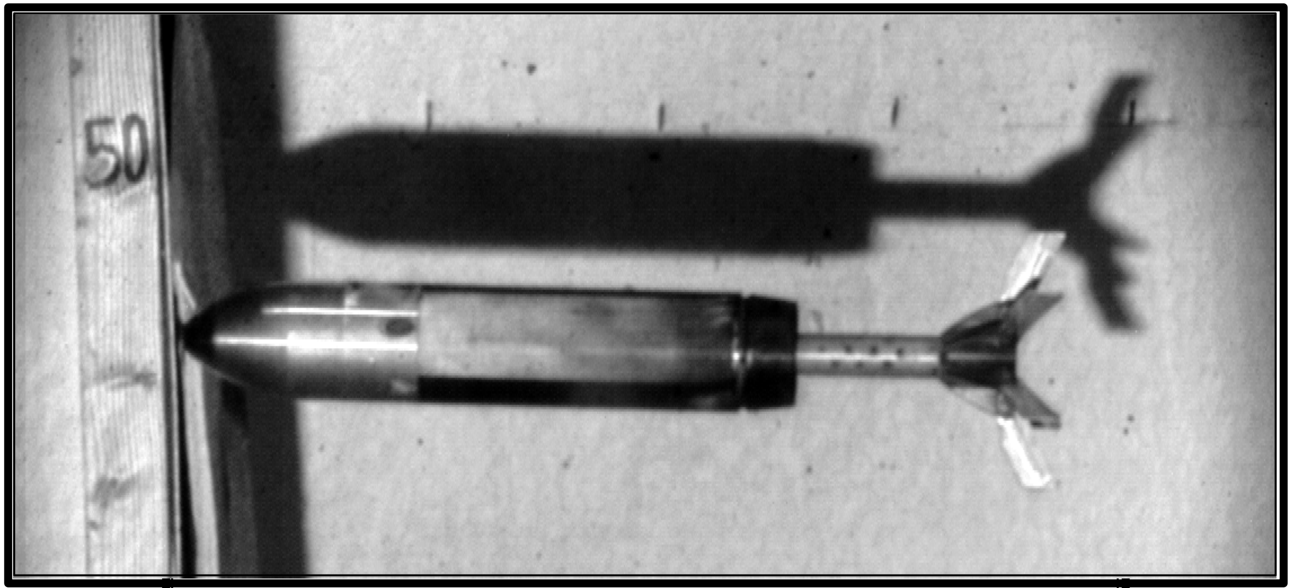


Status

- Completed last year of its Science & Technology Objective (STO) program (RDT&E Line # 6.2)
- Summary of STO program
  - ✓ Level-2 Technical Data Package (3D Pro-E)
  - ✓ Rocket Motor Interior Ballistic Characterization via static live fire
  - ✓ Six-Degree of Freedom (6-DOF) modeling data
  - ✓ Structural Integrity at high-G environment of composite components via live fire at top charge
  - ✓ Live fire tested design of spring actuated 6-Fin Assembly
  - ✓ Structural Integrity at high-G environment of VMRI precision device via airgun test
  - ✓ Range Flight Test Demo @ Yuma Proving Ground

XM984 ER-DPICM 120mm Mortar Cartridge

Flat-Angle Live Fire Test – 22 Oct 2001



Test Round in flight 50 feet from muzzle

Objective: To determine structural integrity of redesigned rocket motor components under setback environment of live fire.

- **Muzzle velocity: 326.1 m/s**
- **Chamber pressure: 12,012 psi**
- **Top zone charge (4)**
- **Good obturation observed from Fast-X camera**
- **Good fin deployment**
- **Stable flight (low angle of attack)**

Static Rocket Tests

29 August 2001

Firing No. SK7694-E-12

YPG Flight Test – 11 October 2001

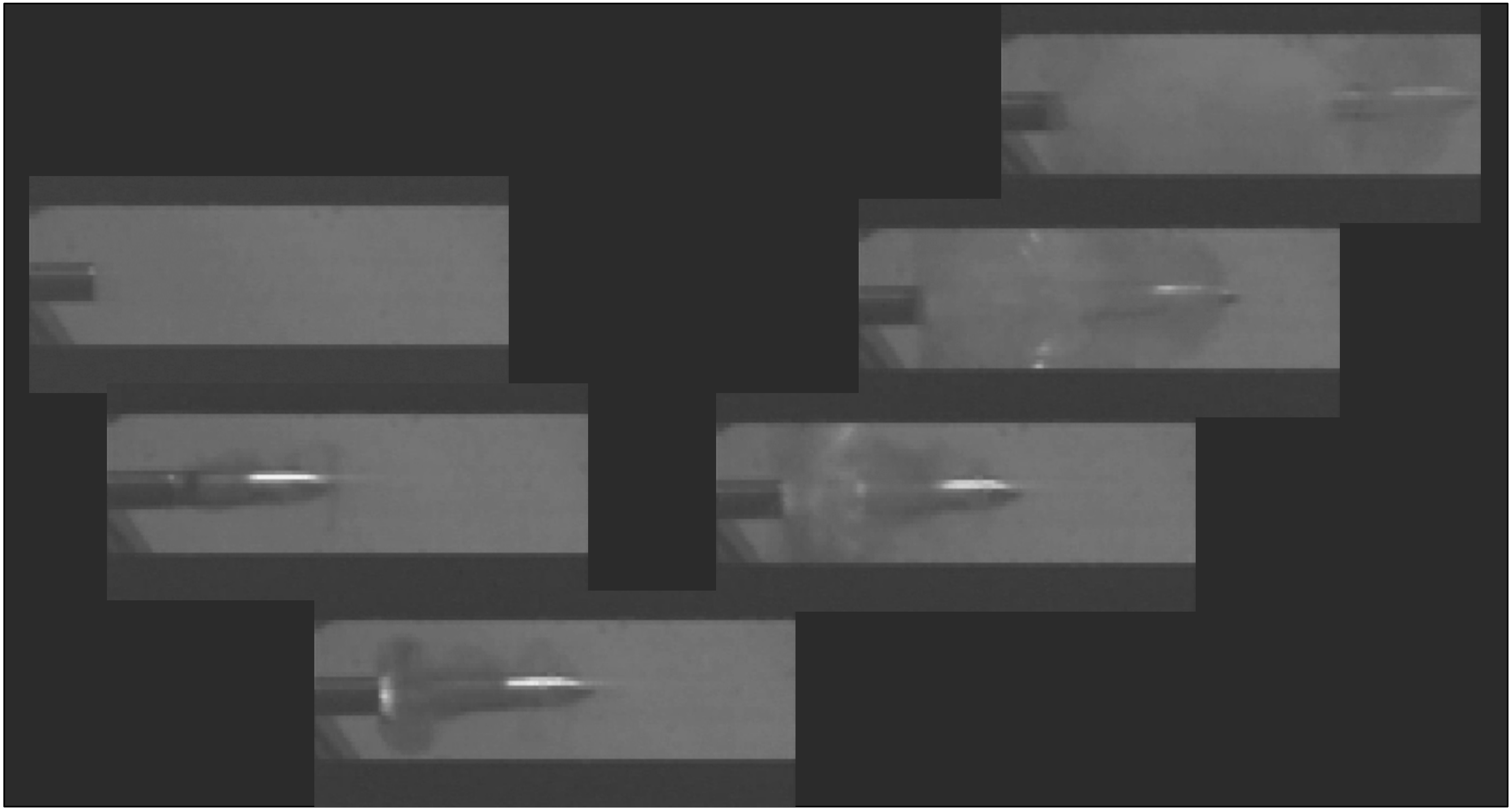
Video of First Test Round (TRN-3124)

High Speed Video
XM984 Rocket Motor Function

XM984 ER-DPICM 120mm Mortar Cartridge

YPG Flight Test – 11 October 2001

Obturation of Third Test Round (TRN-3126)



YPG Flight Test – Recovery

Recovered Test Rounds

Intact Fin Assembly from Test Rnd #1

YPG Flight Test – Exit Criteria

- ✓ Demonstrate increased range performance from 5.4 to 8.8 Km +/- 10%.
- ✓ Normal functioning of rocket Motor and flight trajectory.

Range Growth Potentials

• Optimize rocket propellant	+ 0.4-0.6 Km
• Increase rocket motor length	+ 1.0 Km
• Reduce air frame drag	+ 1.0 Km

XM984 ER-DPICM 120mm Mortar Cartridge

YPG Flight Test – Official Test Data

Flight Performance

Rd #	Rocket Delay	Muzzle Velocity Weibal	Muzzle Velocity Mark V	RANGE	DEFL	L / R	TIME TOF	TIME STDV
3124	6	330.9	330.6	7823	36	R	58.54	.30
3125	6	331.4	331.5	7835	12	L	57.05	.23
3126	12	330.1	330.5	8670	234	L	58.73	.00

Rocket Motor

Rd #	Rocket Motor Ignition	Rocket Motor Burn-out	Motor Burn Time	Velocity at Ignition	Velocity at Burn-out
3124	6.3	9.4	3.1	205.0	328.0
3125	6.0	9.0	3.0	211.0	330.0
3126	11.95	15.06	3.1	144.0	283.0

Range increase by 23% over standard 120mm mortar

Continued Development

- Refine rocket motor design to deliver better thrust impulse and reduce airframe drag for extended range test at YPG
- Continue proof-of-principle efforts for the Velocity Measurement / Rocket Ignition (VMRI)
- Process design and fabrication of composite base, tailboom, and fin assembly
- Engineering bench tests of expulsion charge system
- Fabrication and testing prototype multi-function fuze
- Development of pattern distribution system for submunition

Summary

- APPROVED REQUIREMENT
- IMPROVED SURVIVABILITY
- INCREASED EFFECTIVENESS
- REDUCED LOGISTICS BURDEN
- ENHANCED PRECISION
- SYSTEM COMPATIBILITY
- ACCOMODATES VARIOUS PAYLOADS
- LOW COST
- PROVEN DESIGN CONFIGURATION

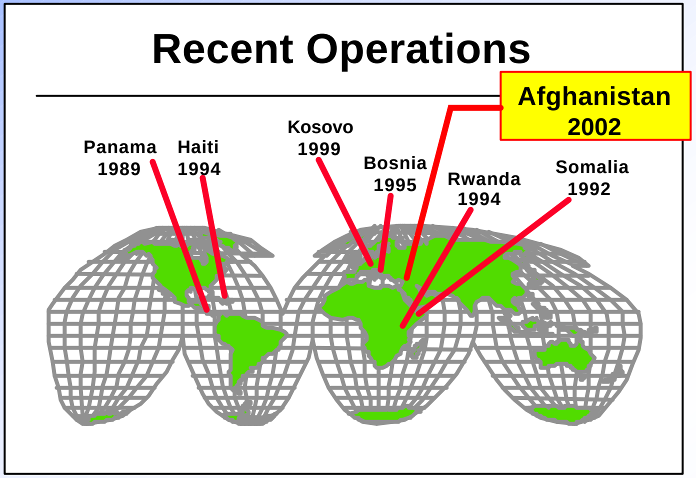
2002 International Infantry and Joint Services Small Arms Symposium and Exhibition

XM 395
Precision Guided Mortar Munition
(120mm PGMM)

Anthony Pezzano
PM Mortars

PEO Ammunition

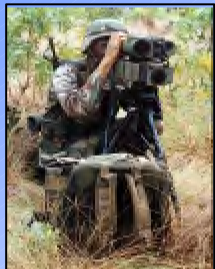
Threat



There is an immediate and significant need to responsively engage small protected targets from a distance while minimizing collateral damage.

- **Identified Deficiency**
  - Forces unable to responsively neutralize time urgent, protected targets.
  - Enemy damages blue forces in relative safety.
- **Mission Need**
  - Organic, responsive, indirect fire, precision strike munition that has significant capability against a variety of protected targets confronting the maneuver commander in a variety of operational circumstances.
- **Primary Targets**
  - Threats within protective cover
    - Threats
      - Shoulder launched grenade launchers (RPG-7s)
    - Automatic Weapons (machine guns, crew served weapons, etc.)
      - C2 nodes, command posts, observers, etc.
    - Protective cover
      - Bunkers, fortified positions
  - Buildings, structures
- **Secondary Targets**
  - Vehicles (moving and stationary)
    - Light Wheeled
    - Heavy Re-supply

Mortar Infrastructure In Place




Forward Observers and Designators

Mortar Fire Control System

Towed 120mm
(Ground Mounted)


Vehicle Mounted 120mm
M113 Variant IAV (BCT)

- **Fielded or Development Programs**
  - **120mm Mortars in current infrastructure**
    - **<u>120mm Mortar Platforms</u>: M121 (carrier-mounted), M120 (towed mortar), Interim Armored Vehicle - Mortar Carrier (IAV-MC)**
    - **<u>120mm Mortar Munitions</u>: HE, Smoke, Illumination (Visible & Infrared)**
  - **Light-weight Laser Designator Range Finder (LLDR)**
  - **Fire Control / Command & Control Links**
    - **Mortar Fire Control System (MFCS)**
    - **Advanced Field Artillery Tactical Data System (AFATDS)**

PGMM
Compatible with Existing and Future Battalion Indirect Fire Systems

Precision Guided Mortar Munition (PGMM)

Lethality for Army Transformation

Accuracy: 1m CEP

Max Range: 15 km

Weight: <35 lb

Length: <40 inches

Legacy

Interim

Objective

Prime Contractor:
- Lockheed Martin

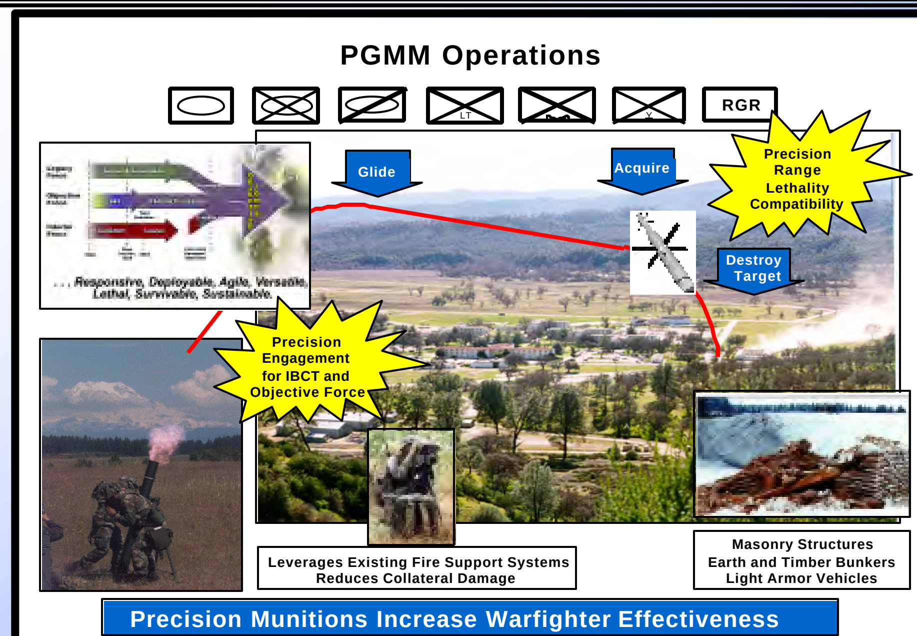
Major Subs:
- Diehl (Airframe & CAS)
- Draper (Gyro)

Description

- 120mm Precision Guided Mortar Munition
- Hit point targets with Precision
- Incapacitate Personnel protected within:
  - Earth and timber bunkers
  - Masonry walls
  - Lightly armored vehicles
- Engage targets at Extended Ranges – 12 km Required, 15 km Desired
- Compatible with the 120mm Mortar System

Status

- Advanced Technology Demonstration (ATD) complete
  - ATD Design Assessed at TRL 5 by Army Warfighter Tech Council (WTC)
- Component Advanced Development (CAD: 02-03)
  - Transition to Acquisition System
- Blocking Requirements to Achieve Success
- Acquisition Program Funded, beginning FY04
- Production Funded, beginning FY07
- LSI shows PGMM is #1 killer in Area of Operations

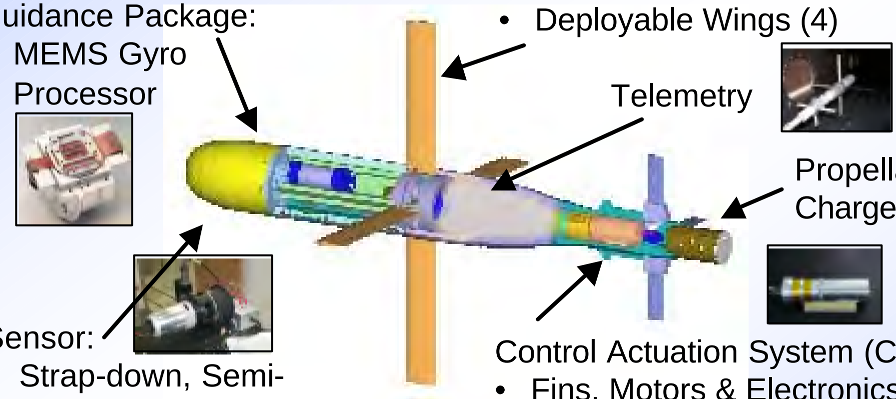


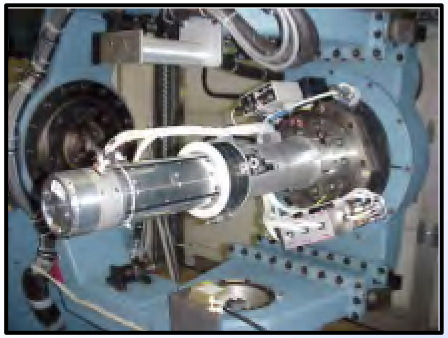
Flight Test Video Cilp

- **Demonstration Objectives**
  - fin deployment at launch
  - wing deployment at apogee
  - pre-programmed maneuver
  - controlled glide to extended range
  - target impact

PGMM TRL Assessment

- PGMM subsystems successfully live-fire tested and performance tested (post Hi-G).
  - No warhead or fuze
- Flight Demonstration hardware completed Hardware in the Loop acceptance testing (Sep 01).
- Flight Demonstration completed 18, 19 October at YPG.
  - Round 1: Telemetry / squib fire electronics failure at launch, round flew ballistic (no guidance)
  - Round 2: Flew stably to end game, missed target




Hardware-in-the-Loop (HWIL)


ATD Demonstration

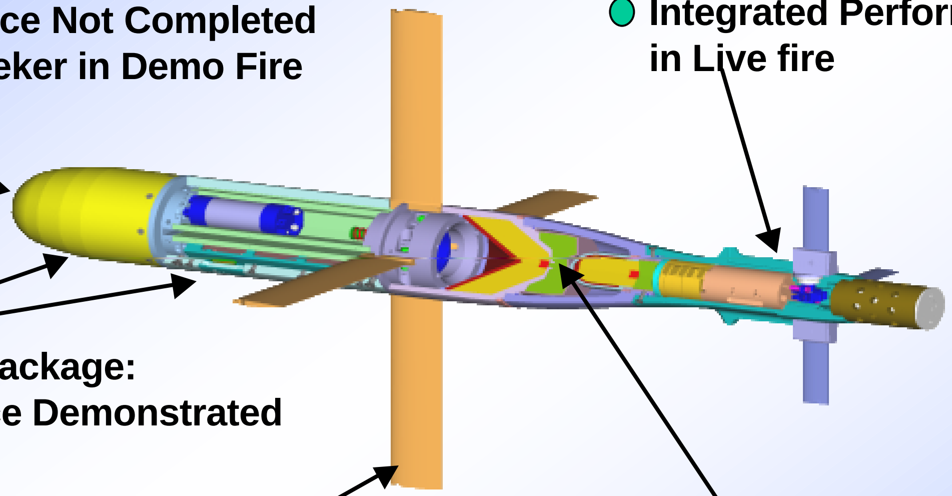
Subsystem	Current TRL	ATD Exit Criteria (Subsystem Test, Live Fire)
Guidance Package	**6**	**Subsystem Live Fire Complete, Performed in System Demo (OCT 01)**
Airframe	**6**	**Subsystem Live Fire Complete, Performed in System Demo (OCT 01)**
CAS	**6**	**Subsystem Live Fire Complete, Performed in System Demo (OCT 01)**
Sensor	**5**	**Subsystem Live Fire Complete, Not Validated in System Demo**
Warhead/Fuze	**3**	**Not part of Exit Criteria, studies performed**

PGMM ATD Design Assessed at TRL 5

PGMM Technical Approach

- Sensor
  - Subsystem Testing Completed (Hi-G)
  - Integrated Performance Not Completed
    Demonstrate SAL Seeker in Demo Fire

- Control Actuation System (CAS) (Fins, Motors & Electronics)
  - Integrated Performance Demonstrated in Live fire



- Guidance & Electronics Package:
  - Integrated Performance Demonstrated in Live fire

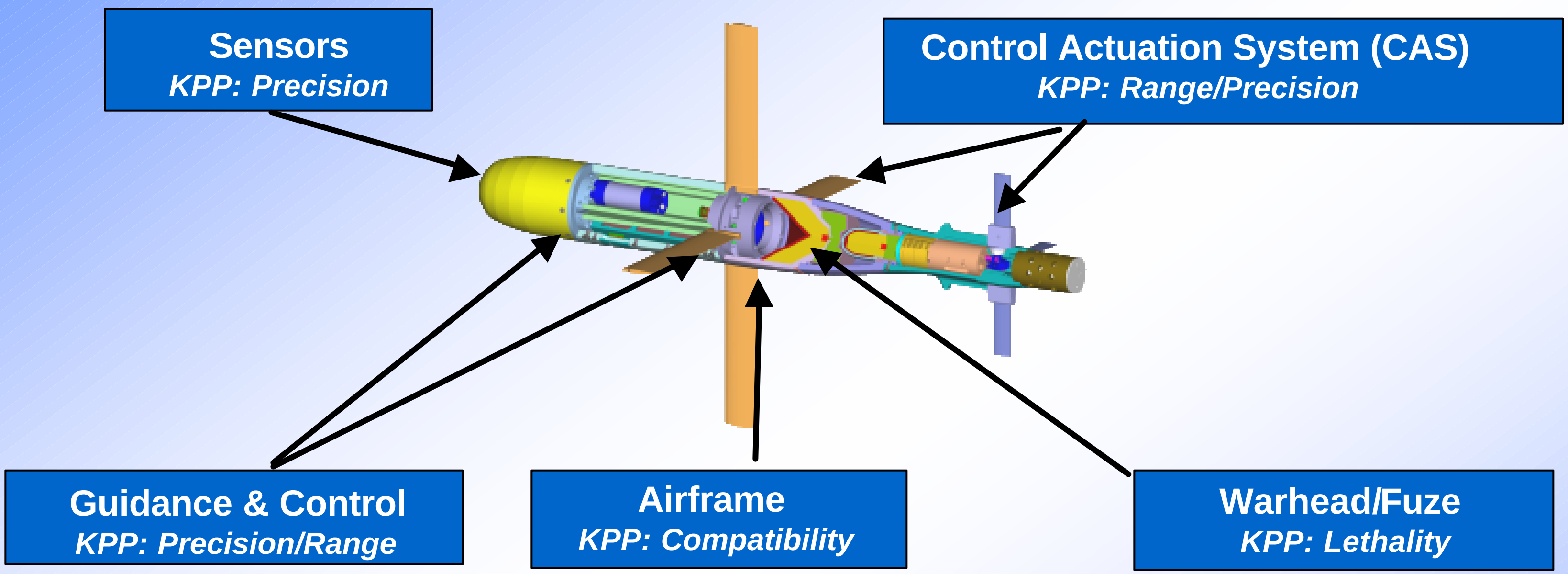
- Airframe (Deployable Wings):
  - Integrated Performance Demonstrated in Live fire

- Warhead/Fuze:
  - Initial Assessment Identifies Existing Mortar Qualified Sub Components to Meet Block 1 Requirements:
    - Point Detonating (PD) Fuze
    - PAX Family of Unitary Explosives

Key:
- Completed through Form, Fit & Function
- Not Completed (less than TRL 6)

Mature Design on Demonstrated Components,
Integrate Existing Hardware/Materials

Commonality Leverage



Current DOD Program/Product	Common Components	Application	Life Cycle Phase	Leverage Potential
Excalibur	CAS, G&C Airframe	155mm Howitzer	SDD	Direct
TERM	Sensors, CAS, G&C	120mm Tank	S&T	Direct
ERGM	CAS, G&C, Airframe	5” Navy Gun	SDD	Direct
TCM	CAS, G&C, Airframe	155mm Howitzer	S&T	Indirect
ER-DPICM	Airframe	120mm Mortar	S&T	Direct
Hellfire/Javelin	Airframe, Warhead	Missile	SDD/PAA	Indirect

Direct: Common Components   Indirect: Similar Components; Learning Curve Acceleration

Summary

Blocked Design Approach

Allows for Affordability

Reduces Risk

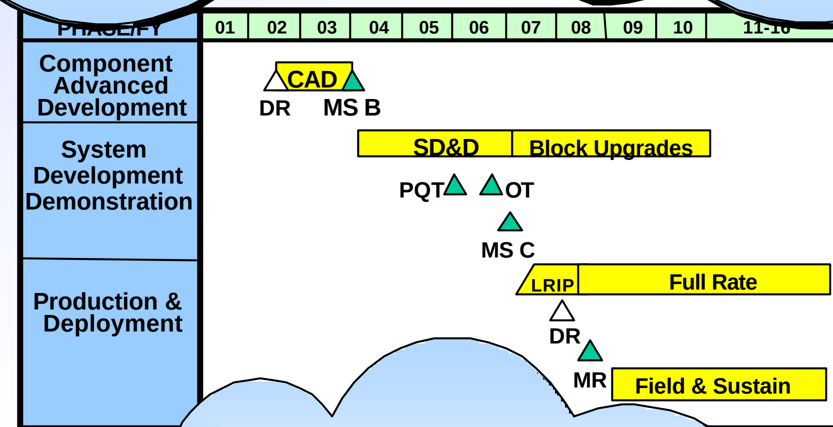
Provides Potential for Early Delivery

Improves Design with Technology Transfer

Excellent Leverage Opportunities for PGMM Exist

PGMM Critical Sub-Systems Identified and Cross-Referenced

Leverage Existing Training Methodology/Components/Technologies



Future Growth Technologies

Low Cost SAL Sensors and Electronics

Producibility of Critical Sub-Components

G- Hardened Components

Advanced Warheads

Multi-Option Fuzes

Lightweight Aero-Structures

North Atlantic Council
NATO Army Armaments Group
Land Group 3 for Close Combat, Infantry

(Team of Experts)
Working Group 2 for MOUT/NLW

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NATO Army Armament Group

NPAG

Land Group 1
Digitized Battlefield Interoperability

Land Group 2
Close Combat Armour

- WG/1 Vetronics

Land Group 3
Close Combat Infantry

- SG/1 S.A. Ammo Stdzn.
- WG/1 PDW Caliber
- WG/2 MOUT/NLW

Land Group 4
Surface to Surface Artillery

- SG/2 Accuracy Ballistics Explosives

Land Group 5
Army Air Defence

Land Group 6
STANOC & Electronic Warfare

- SG/5 Electronic Warfare
- SG/7 Counter Surveillance
- WG/1 UAVs
- WG/2 Imagery Data

Land Group 7
Joint Nuclear Biological Defence

- SG Air
- SG Naval
- SG Nuclear Protection
- SG SIBCRA
- SG Challenge
- WG/1 on Skin toxicity

Land Group 8
Simulation Interop For Joint Training & Operational Support

Land Group 9
Battlefield Engineering

Land Group 10
Battlefield Helicopters

Joint Project Group 28/30
VSHORAD SHORAD

Project Group 31
Acqueous Decontaminants

Topical Group 1
Soldier System Interoperability

- Responsible for dismounted Infantry Material
- Participation: BE, CA, FR, GE, GR, IT, NL, (SW),UK,US WG 2 is open to all PfP nations
- Mission:
  - Interoperability of MOUT-specific materiel to include NLW
  - Harmonization of Concepts and Doctrine in MOUT operations
  - Execution of DCI Project for NLW as the LG.3 agent
    - Specifics include the fielding of a NATO NLCS by 2005 for crowd control; investigation of harmonized doctrine, tactics and materiel for area denial to persons and vehicles as well as clearing of facilities
- WG.2 will very likely disband after 2005

Working Group 2 for MOUT/NLW Continued

- Defense Capabilities Initiative; the #1 priority of the NAAG
  - - NATO NLCS effort is a portion of NLW DCI project
- Responsible for fielding a Non-Lethal Capabilities Set by 2005
  - – Based on US NLCS; primary purpose is crowd control
  - – Includes Core (agreed) and Shell (not yet agreed) materiel items
  - – Shell items are also a compilation of national capabilities
  - – Currently there are no munitions in Core set
- Potential for collaborative future development
- National ROE's and legal issues a problem

NATO NLCS CORE ITEMS

1. Face Shield / Helmet Visor , Non-Ballistic (#1)
2. Body Shield, Non-Ballistic Large or Small (#2)
3. Riot Shin Guards, Non-Ballistic (#3)

* 4. Nape Protector

* 5. Forearm Protector or Glove

6. Protective Vest **(Not Physically in Set)**

7. Baton (Riot Stick) – Wooden (#7)
8. Bullhorn, Portable (#8)
9. High Intensity Light, Individual (#11)
10. High Intensity Light, Large (1900m) (#13)
    a) High Intensity Light Individual Replacement Kit (Bulb) (#12)
    b) Batteries (#55)
11. Flex Cuffs (#15)
12. **Launcher, NL Point Fire, Blunt Impact Devices** **(Not Physically in Set)**
13. Munitions, NL Point Fire, Blunt Impact Devices
    Long Range (Effective Range: 40 meters
14. Munitions, NL Point Fire, Blunt Impact Devices
    Short Range)
15. Caltrops (#31)
16. Riot Training Suit with Accessories (#32)
17. Riot Training Bag (#33)

*- Proposed as Core; pending final National positions by GE, US

Supporting Material Not Found in NATO NLCS:

•Razor Wire
•Engineer Barriers
•Vehicles

Other Essential Items Not Found in NATO NLCS:

•RoE Cards
•Training (Tactics, Techniques, Procedures)
•Training Scenarios
•Training Package & Facilities (including simulators)

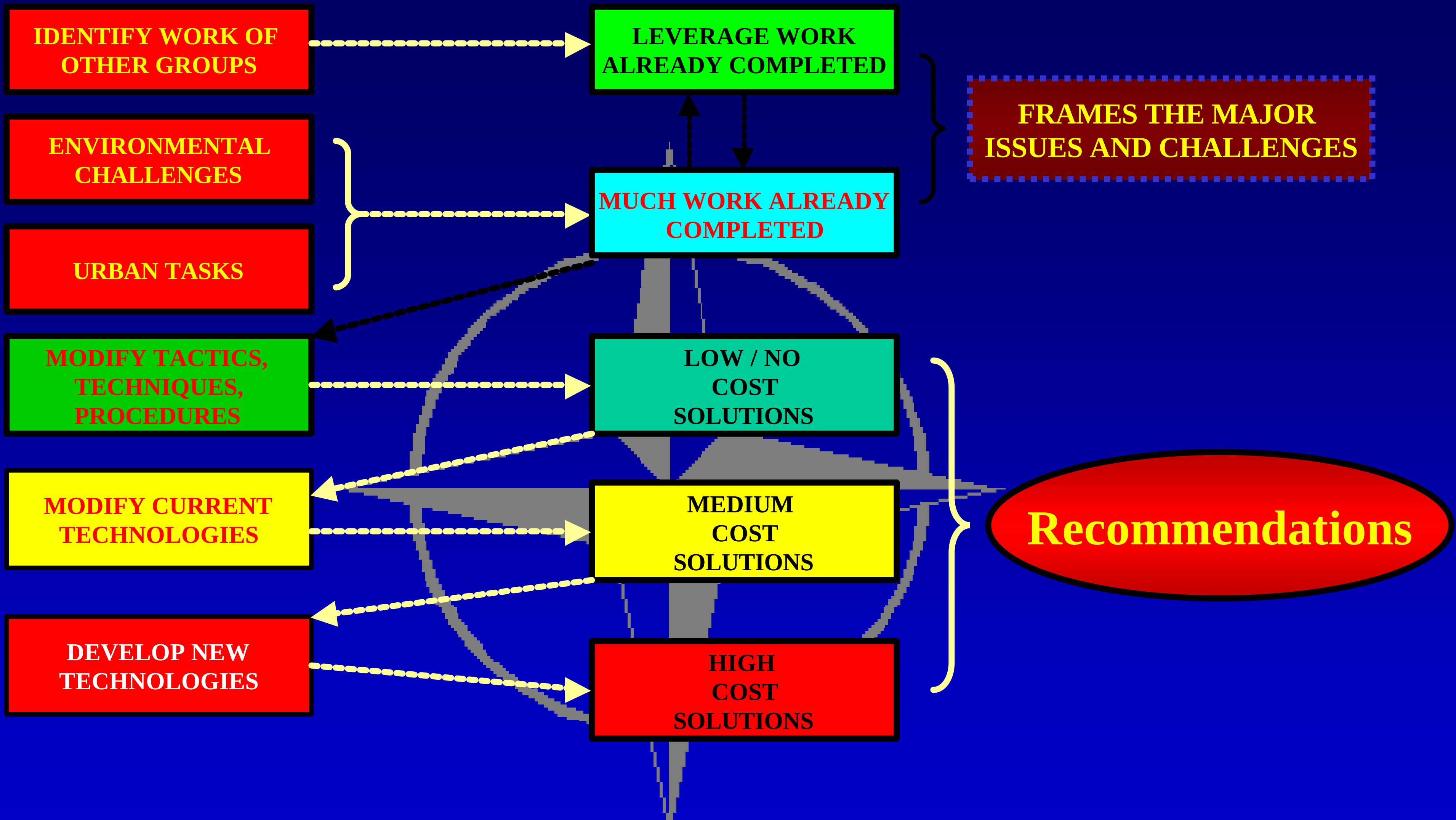
NATO NLCS SHELL ITEMS

1. Face Shield, Ballistic (#4)
2. Body Shield, Ballistic (#5)
3. Inserts for Protective Vest, Light
4. Inserts for Protective Vest, Heavy
5. Shin Guards, Ballistic (#6)
6. Bullhorn, Ground Mounted (#9)
7. Bullhorn, Back Packed (BE)
8. Individual Voice Amplifier (#10)
   (for RCA Protective Gear)
9. 40mm Point Fire Rd, Blunt Impact Device (#44)
10. 40mm Area Fire Rd, Blunt Impact Device (#45)
11. 40mm Carry Pouch (#30)
12. 37mm Riot Gun (#64, UK)
13. 37mm Baton Rd, Blunt Impact Device, Short Range (#65, UK)
14. 37mm Baton Rd, Blunt Impact Device, Long Range (#66, UK)
15. 12 Ga Shotgun (#24)
16. 12 Ga Point Fire Rd, Blunt Impact Device (#40)
17. 12 Ga Area Fire Rd, Blunt Impact Device (#41)

NATO NLCS SHELL ITEMS

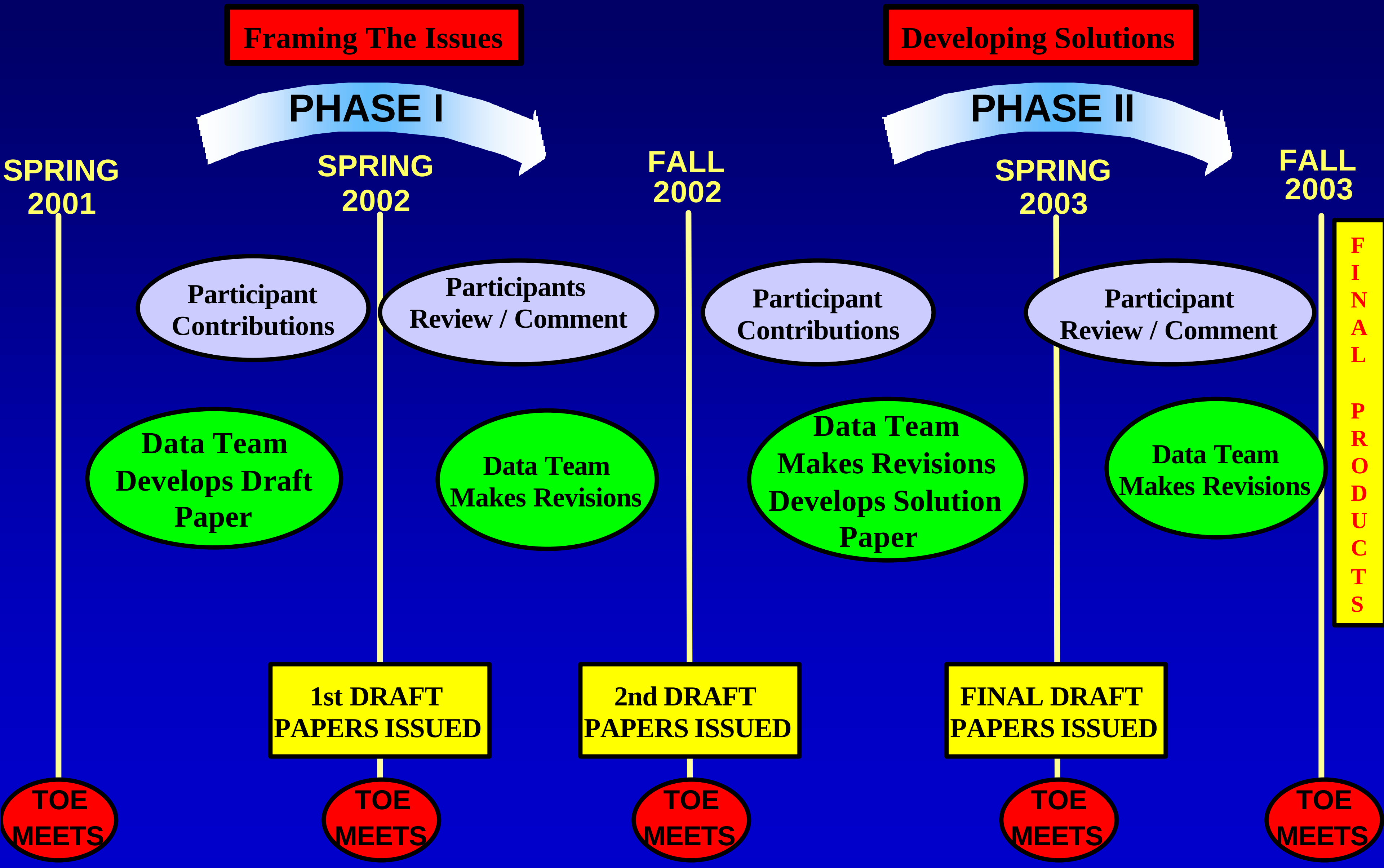
18. 12 Ga Aerial Distraction (Flash Bang) Rd (#42)
19. 12 Ga Rds Utility Pouch (#25)
20. 12 Ga Butt Cuff Carrier (#26)
21. 12 Ga Launching Cup (#27)
22. 12 Ga Launching Cup Ctg (#43)
23. 12 Ga Dummy Rd (#28)
24. Hand Thrown / 12 Ga Launched, Blunt Impact Device (#49)
25. Hand Thrown Grenade, Diversionary (Flash/Bang) (#48)
26. 5.56mm Rifle Muzzle Launched Point Fire, Blunt Impact Device (#46)
27. 5.56mm Rifle Muzzle Launched Area Fire, Blunt Impact Device (#47)
28. Stinger Tire Puncturer (UK)
29. Portable Vehicle Arresting Barrier (#35)
30. Vehicle Mounted Grenade Launcher (VMGL) (#34)
31. Grenade, Area Fire, Blunt Impact Device for VMGL (#50)
32. Grenade, Distraction (Flash/Bang) for VMGL (#51)
33. Grenade, RCA (Live) for VMGL (#59)
34. Grenade, RCA Simulant Trainer for VMGL (#60)
35. Fire Extinguishers
36. Cameras (Video)

STUDY METHODOLOGY



Methodology Will Produce The Lowest Cost, Most Effective Solutions To Enable NATO Forces To Perform Full Spectrum Urban Operations With Significantly Reduced Risk To Our Forces and Limited Collateral Damage.

TEAM OF EXPERTS URBAN STUDY TIMELINE



Design and Development
of the
OICW Miniature Fire Control System

P.Plocki (Brashear LP), R.Volz (US Army ARDEC) and A.E.Brindley (Alliant Techsystems)

2002 International Infantry & Joint Services
Small Arms Systems Section Symposium

May 13 - 16, 2002
Atlantic City, NJ

Objective Individual Combat Weapon
Target Acquisition / Fire Control System

Content

• Describe challenges and accomplishments associated with developing a miniature, lightweight, full function fire control system for OICW

• Discuss system trade-offs required to obtain optimum performance in the face of severe limitations on size, weight and power.

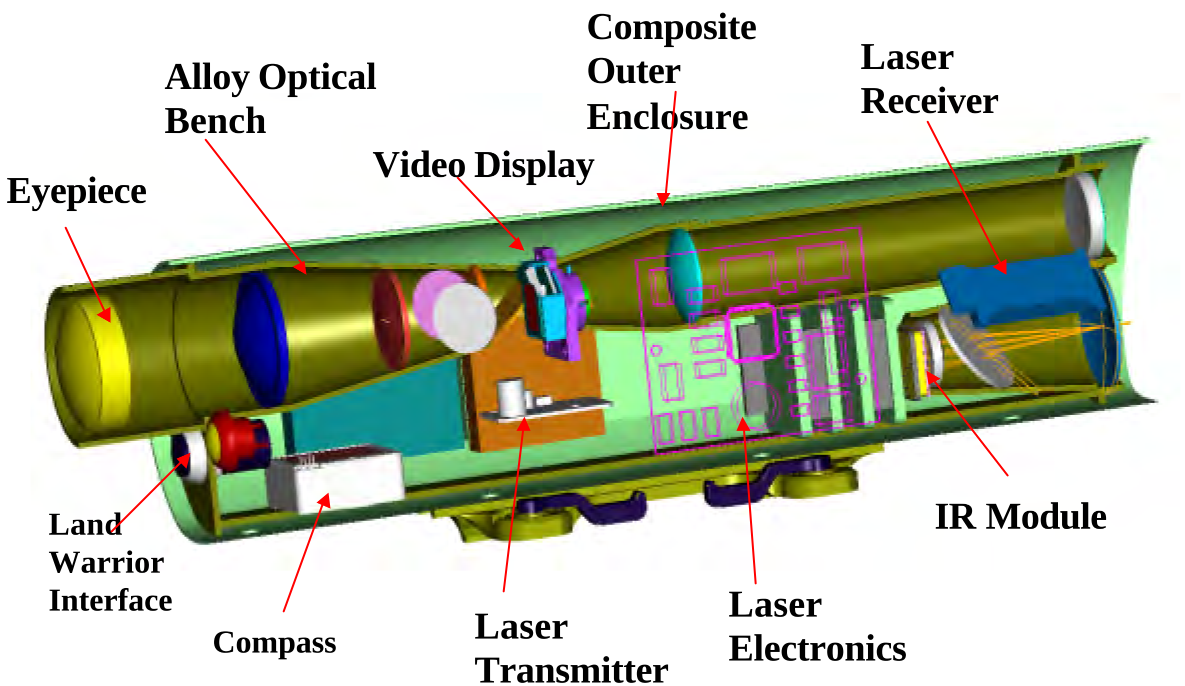
• Describe rangefinder, thermal imager, mechanical structure, display and overall electrical architecture.

• Present test results and examples of sub-system performance

Overview - OICW TA/FCS

- A full solution, day/night, multifunctional system providing:
  - A ballistically adjusted weapon aimpoint
  - Range/ballistics based High Explosive Air-Burst fuze setting
  - Target imagery, range and location data to Land Warrior

Integrates laser rangefinder, direct view optics, thermal imager, day video imager, multifunctional display, compass/inclination/cant sensor, ballistic processor, fuze setting electronics and environmental sensors within a single housing



TA/FCS Maturation

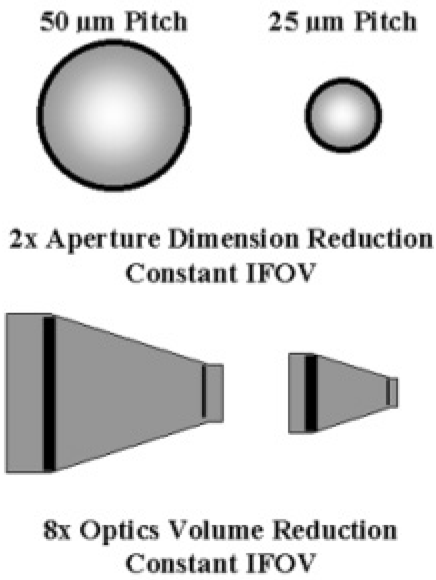
Primary system challenge is to achieve a significant weight reduction

Past: (FY00)	Current: (FY02)	Future: (FY08)
> 7 lbs. 3X magnification 10^{o} Horiz. FOV .7 $P_{R/D}$ @700 m Thermal not integrated 12W Avg Power 40W Peak power Not Ruggedized Limited environments	= 2.72 lbs. 2X magnification 13^{o} Horiz. FOV .9 $P_{R/D}$ @500 m Fully integrated ~3W Avg Power ~9W Peak power Ruggedized Full Mil Environments Land Warrior Compatible	< 2.72 lbs. Enhanced features: Target tracking Multi-function laser Sensor fusion OFW compatible

TA/FCS contributed >60% weight reduction with increased operational capabilities

Thermal Imager

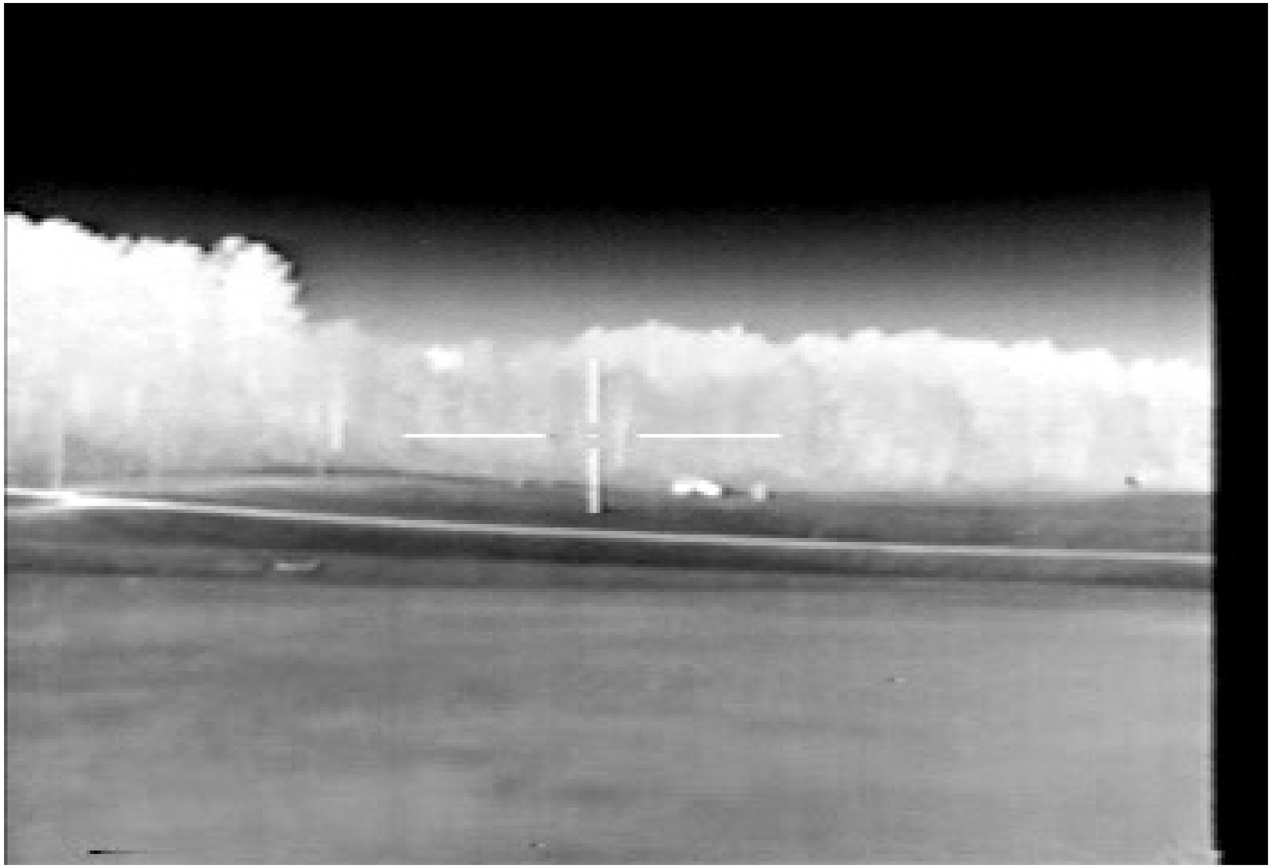
- Evaluated various Uncooled IR technologies - microbolometer(Vox) & Amorphous Silicon , Ferro-electric (BST) Thin & Thick Film, U-cantilever technology(capacitive)
- Selected thermal module candidates for further investigation:
  - 320x240~50µm
  - 640x480~25 µm
  - 320x240~25 µm
- Emerging Uncooled Thermal Technology - Mini-Thermal Module 320 x 240 ~25 µm pixels pitch - Size ~ 26 mm diameter by 26 mm length - <50mk NEDT



25 µm pixel provide significant savings in weight/size, power, and cost -

Thermal Imager Range Performance

Benign Conditions



Walking personnel & vehicle target at 500 meters
microbolometer sensor 320 x 240 - HFOV=15^0

Selected largest FOV possible to meet recognition range requirements, provide situational awareness, and reduce system size and weight

Laser Rangefinder Selection Process

- Challenge is to obtain <1 meter accuracy on moving personnel target from a shoulder supported fire control system

- Approach

    Laser technologies studied to identify test bed candidates

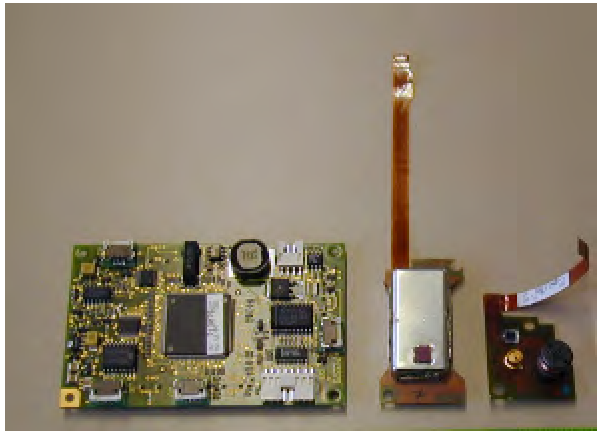
    Designed/built/tested two laser rangefinder test beds

    Developed & utilized Probability of Correct Lase model to optimize LRF parameters for OICW application

Both of our rangefinder test beds demonstrated the performance needed to achieve the required weapon system lethality

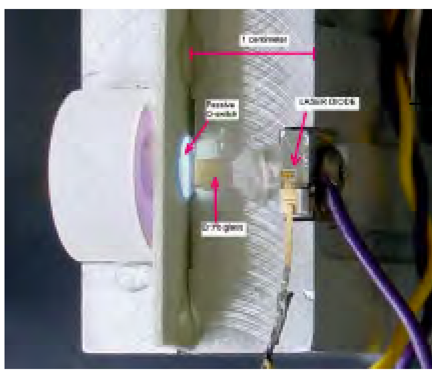
Laser Rangefinder Technology

Semiconductor LRF

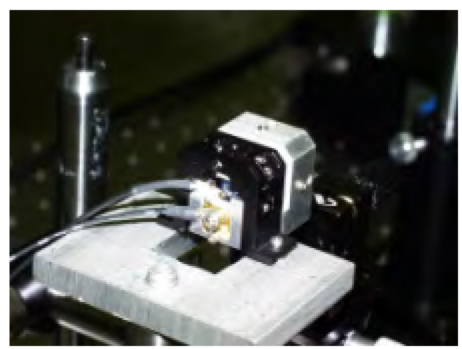


Investigated over 20 different laser rangefinder systems and downselected to these two technologies

Erbium microchip laser transmitter



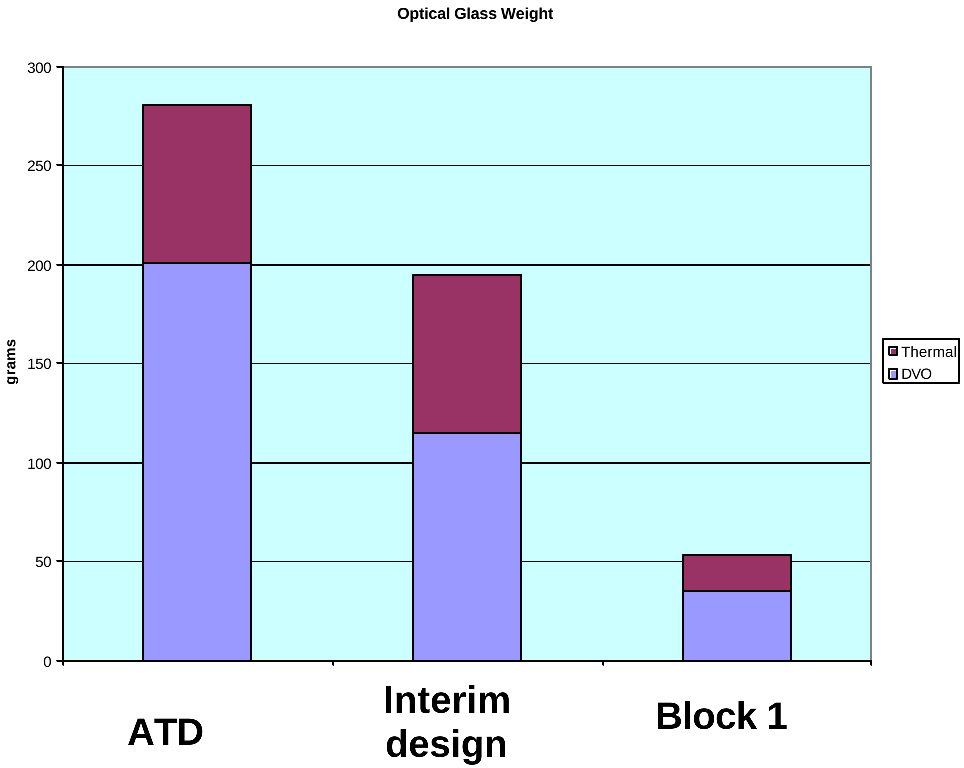
Roadmap



Tested Erbium Laser Tx

Both LRF technologies have been field tested with excellent probability of correct lase & range measurement accuracy results

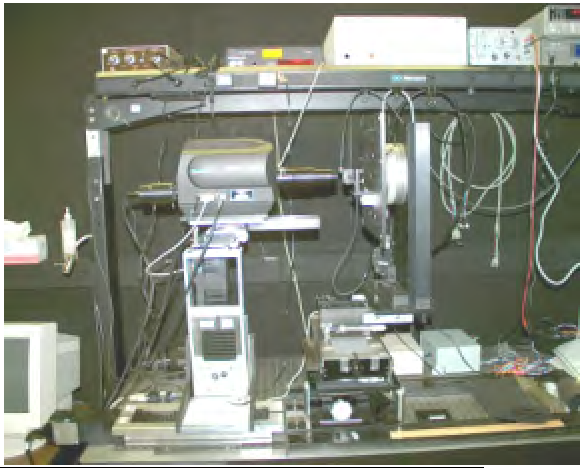
Optical Highlights



Trade studies of optical performance versus weight resulted in a hybrid optical design with both reduced weight and improved performance over ATD

Display Study

Lab Testing



Display symbology overlay on DVO

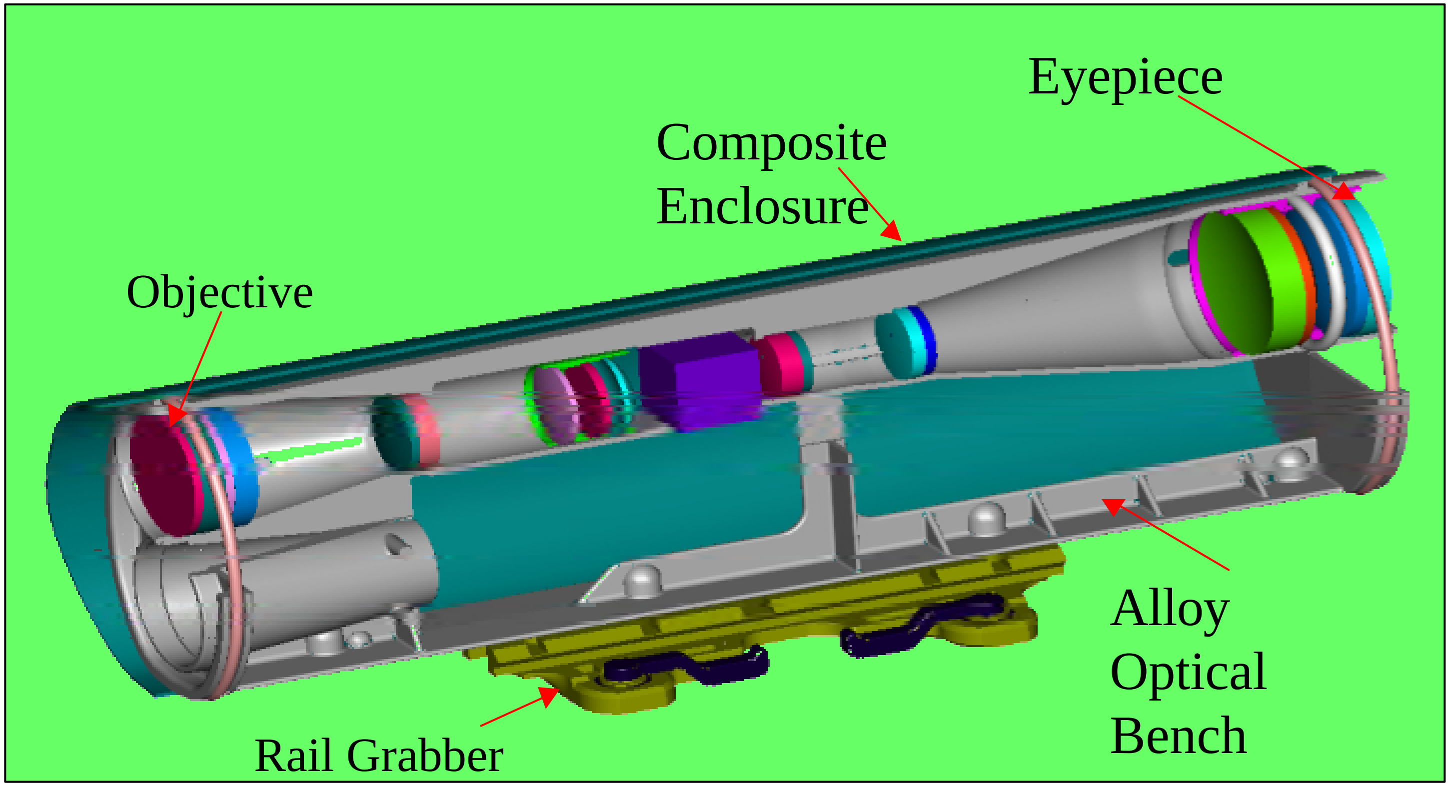
- Extensive investigation of numerous color video display technologies

- Down selected prime candidates
  - OLED -Organic Light Emiting Diode
  - LCOS -Liquid Crystal On Silicon
  - AMLCD -Active Matrix LCD

- OLED & LCOS display characterization completed at NVESD on 1/4/02
  - OLED brightness of 29.6 ft-L
  - LCOS brightness of 71.9 ft-L
  - Limited environmental test performed

Multifunction display provides thermal/day video & symbology overlay for the direct view optics

Housing & Optical Bench



Extensive materials & process trade study

- Materials (Plastic, Epoxies,Metals)
- Coatings
- Manufacturing Process for production

Environmental Testing
- Weapon Shock
- Drop & impact
- Solar Loading/ Thermal Cycling
- Salt Fog Corrosion
- Adhesive Testing

Highly integrated architecture and two-piece housing provide rugged light-weight structure

Electrical Architecture and Power Supply Challenges

Challenges/Goals

•Define primary battery providing background system draw for ~ 10 hours, weighing only 0.3 lb (tactical) and (0.4 lb training)

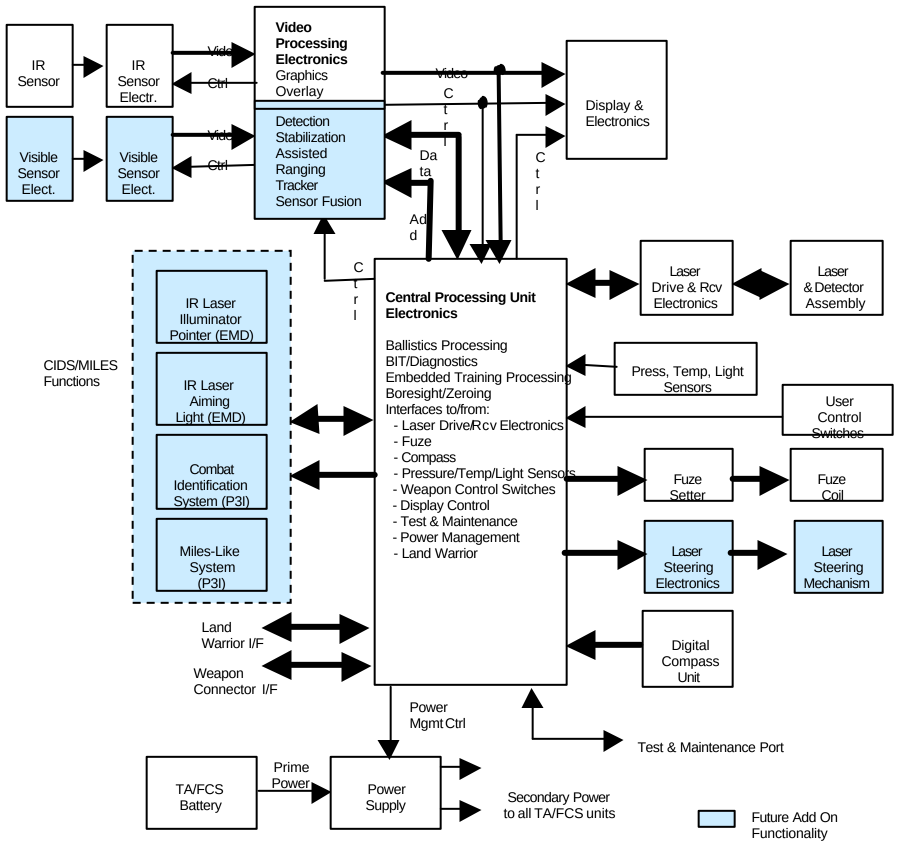
•Provide high current/low energy pulses for fuze setting

•Reduce system power significantly and apply power management techniques to allow small battery with reasonable run time

•Provide battery which will operate at low temperature

•Determining best <u>system level</u> solution for battery location and meet Army battery safety requirements

•Define rechargeable supply for training affordability



Electrical System Achievements

•Reduced FCS electronics power requirement by factor of > 4

•Reduced battery pulse peak current draw from > 12 A to < 5A

•Designed low risk primary battery utilizing $LiMnO_2$ D-cells

Tested from –50°F to +125°F

Verified ability of cells to output sufficient current at low temperature

Established system run time requirement can be met at room temperature and run time degrades gracefully at extreme cold

•Identified approach for rechargeable training battery using Li-ion

•Able to operate from Land Warrior and vehicular power

•Able to shut down redundant functions when used with Land Warrior

•Involving CECOM early to ensure we meet Safety requirements

System battery incorporates Army-approved components for low risk

Summary

•Conducted over 30 trade studies to establish best combination of OICW cost, performance and weight

•Regular involvement of User in establishing trade space and sharing of results as part of Integrated Product Team

•Continual involvement of key government labs (particularly NVESD) and offices in technical activities and decision process

•Major Critical Technology testbed activity - Design/Built/Tested

LRF	(3)	Optical (Hybrid & IR)	(3)
Thermal	(2)	Housing/cover/optical bench	(4)
Displays	(3)	Video Trackers	(2)

•Obtained substantial data base to allow OICW User an informed choice of capability versus weight

Testbed data shows we can meet system requirements within the very challenging FCS weight goal

COMMITTEE OF SMALL ARMS PRODUCERS (CSAP)

2002 UPDATE

Jeff Rankin
FN Manufacturing, Inc.
15 May 2002

Briefing Outline:

- What is CSAP and why do we have a CSAP?
- Who is CSAP?
- The CSAP view of the Small Arms Industrial Base
- Past, current and future discussions, actions and initiatives
- Questions and discussion

- **What is CSAP and why do we have it?**

What is CSAP?

- **U.S. Government Small Arms Procurement, Program Management and Engineering Representatives**
- **Small Arms Industry Representative**
- **NDIA**

Why Do we have CSAP?

- **To provide a forum for Government, Industry and other parties to exchange data and information regarding the Small Arms Industry. Primary focus is on policies, procedures, requirements planning and other initiatives relating to Government procurement, life-cycle costs and the outlook for ongoing industrial base.**

Who is CSAP?

- **This committee is now starting its fifth year and is composed of a chair for industry, a co-chair from TACOM-RI, two representatives from NDIA, the Product Manager (PM) for Small Arms, one representative from TACOM Armament Research, Development & Engineering Center (ARDEC) and six individual memberships representing this industry. The Committee meets two to three times a year. One-half of the industrial membership will normally be reassigned every two years**

• **Current Members:**

Gov. Co-Chair	**Mr. Jimmy Morgan - TACOM RI**
Ind. Co-Chair	**Mr. J.L. Vanderstraeten - FNMI**
PM Small Arms	**LTC Gil Brown**
TACOM ARDEC	**Mr. Kevin Fahey**
Core Ind. Members:	**FN Manufacturing**
	General Dynamic Armament Sys.
	Colt's Manufacturing
Industry Members:	**Barrett Firearms**
	H&K
	Alliant Tech Systems
NDIA:	

- **The CSAP view of the Small Arms Industrial Base:**
  - **NOW**
    - ***Prior to tragedy of 9-11-01**
    - ***After the tragedy of 9-11-01**
  - **FUTURE**
    - ***Capacity issues**
    - ***Budget issues**
    - ***State of Art equipment requirements**

Past, current and future discussions, actions and initiatives

- **Fielding policy for small arms**
- **Best value contracting**
- **Threats faced in the "New Battlefield" environment**
- **Short and long term requirements planning**
- **Small arms acquisition strategy**
- **Industrial base in a downsizing environment**
- **Industry investment in R&D**

- **Small Arms Consortium/National Small Arms Center**

Website Location:

http://ndia.org.committees/csap/index.cfm

FN303
LESS THAN LETHAL SYSTEM

NDIA SMALL ARMS SYMPOSIUM

16 MAY 2002

FN 303 Stand Alone

JEFF RANKIN
FN MANUFACTURING, INC.

FN303

FN 303 Stand Alone

FN 303 Fitted Under M16 Rifle

Less Than Lethal ammo with speed loader

Payloads:
Indelible Marker
Washable Marker
Kinetic/Training
Malodorant
OC
CS/CN
Illumination

Description:

The FN303 is designed to provide a non-lethal / less-than-lethal capability to the military and law enforcement. The pneumatic, 12 gauge, semiautomatic weapon, is fed from a 15 round drum magazine and has a range of 100 meters. This alternative weapon effectively broadens response choices for rules of engagement or use of force.

Features:

• Mode of Operation:	Pneumatic
• Ammunition:	Fires 12 gauge paint ball-like projectiles (marking, CS, malodorant rounds available)
• Weight:	M16 / M4 version approximately 3.5 lbs. Stand alone version weighs < 4 lbs.
• Length:	M16 / M4 version approximately 18 in. Stand alone version approximately 30.5 in.
• Effective Range:	100 meters

FN303 Authorized Less-than-Lethal Projectile

Fin Stabilized Projectile with Payload Capability

OC (Oleoresin Capsicum)

Color Code: Orange

General Specifications

- Mass: 8.5 grams
- Designated Launch Velocity: 280-300 feet/second

Composition:

- Molded Polystyrene Body
- Granular Bismuth Forward Payload
- Internal divider disc with seal as deemed appropriate
- Rear payload capacity

Rear Payload Definition:

- 95% Propylene Glycol of a non-toxic grade or better.
- 5% 2MM SHU OC Concentrate
- Above materials are compounded with Orange non-toxic dye and/or pigment to color as needed

Decontamination:

OC is a severe irritant. Flush the area with water. Soap and Water may be used for the final cleanup.

Product Definition

FN303 Authorized Less-than-Lethal Projectile

Fin Stabilized Projectile with Payload Capability

Washable Paint

Color Code: Fluorescent Pink

General Specifications

- Mass: 8.5 grams
- Designated Launch Velocity: 280-300 feet/second

Composition:

- Molded Polystyrene Body
- Granular Bismuth Forward Payload
- Internal divider disc with seal as deemed appropriate
- Rear payload capacity

Rear Payload Definition:

- Fluorescent Pink Pigment suspended in 100% Propylene Glycol Base
- PG grade is non-toxic or better

Decontamination:

Water soluble material. Soap will assist in cleaning but is not a necessity. Dries to a powdery residue.

<u>Product Definition</u>

FN303 Authorized Less-than-Lethal Projectile

Fin Stabilized Projectile with Payload Capability

<u>Training Round</u>

Color Code: Clear

<u>General Specifications</u>

- Mass: 8.5 grams
- Designated Launch Velocity: 280-300 feet/second

<u>Composition:</u>

- Molded Polystyrene Body
- Granular Bismuth Forward Payload
- Internal divider disc with seal as deemed appropriate
- Rear payload capacity

<u>Rear Payload Definition:</u>

- 100% Propylene Glycol of a non-toxic grade or better.
- Clear with no additives.

<u>Decontamination:</u>

Water soluble material. Soap will assist in cleaning but is not a necessity.

Product Definition

FN303 Authorized Less-than-Lethal Projectile

Fin Stabilized Projectile with Payload Capability

Indelible Paint

Color Code: Bright Yellow

General Specifications

- Mass: 8.5 grams
- Designated Launch Velocity: 280-300 feet/second

Composition:

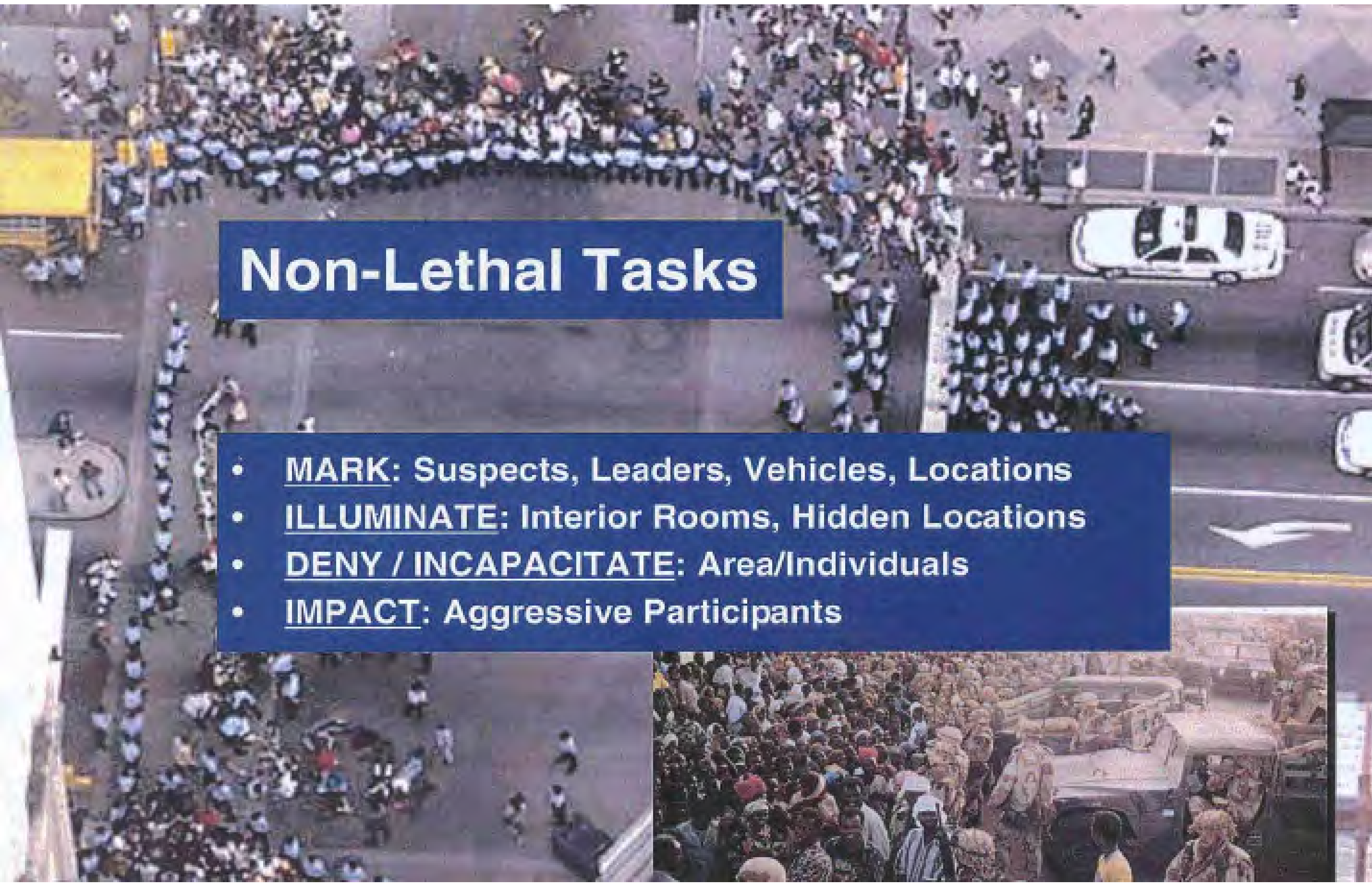
- Molded Polystyrene Body
- Granular Bismuth Forward Payload
- Internal divider disc with seal as deemed appropriate
- Rear payload capacity

Rear Payload Definition:

- Latex based polymeric paint. Becomes an indelible marking compound when fully cured

Decontamination:

Soap and water will cleanup while uncured. Fully cured material requires mechanical or petrochemical solvent removal.


Non-Lethal Tasks
• MARK: Suspects, Leaders, Vehicles, Locations
• ILLUMINATE: Interior Rooms, Hidden Locations
• DENY / INCAPACITATE: Area/Individuals
• IMPACT: Aggressive Participants

TACOM

Lethality, Survivability, Mobility and Sustainment for America's Army

13-16 May 2002

NDIA Joint Services Small Arms Conference

Atlantic City, NJ

Development and Demonstration of a MEMS-based Safety and Arming Device for the 20-mm OICW Fuze

US Army TACOM ARDEC Fuze Div.
AMSTA-AR-CCF-A
Adelphi, Maryland
301-394-0754

Charles H. Robinson, ME (briefer)
Robert H. Wood, ME
Thinh Q. Hoang, ME
David Hollingsworth (NAWC-CL)

Outline

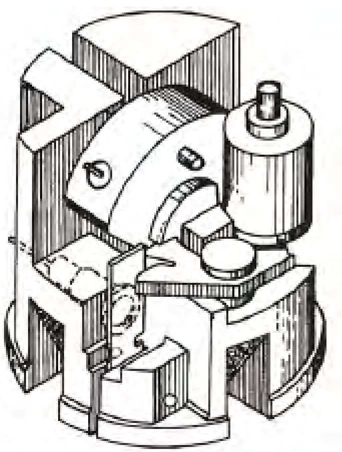
- Review
- MEMS Fabrication
- Assembly
- Testing
- Results
- Conclusions

Micro-Electro-Mechanical Systems Based S&A

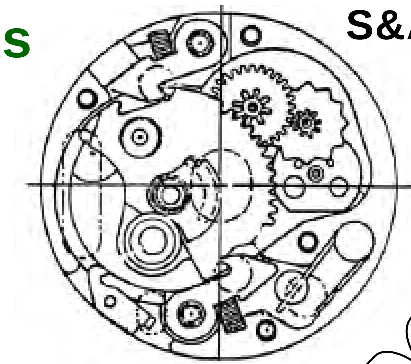
- **Goal - Develop, demonstrate, and evaluate:**
  - → MEMS mechanical S&A device for 20-mm OICW weapon system, and
  - → Compatible micro-scale firetrain (MSF)
- **Approach**
  - → MEMS "inertial mechanical logic" maps S&A functions to planar domain
  - → New methods of assembly
  - → New approach to out-of-line energetics – micro-scale firetrain (MSF)
  - → Demonstrate in laboratory and ballistic tests (5,000 to 80,000 Gs)
- **Why OICW?**
  - → Reduce *cost*, weight, volume of S&A (lethality and affordability)
  - → Cost (including firetrain): several $$ in production quantities of millions
- **Why MEMS? (micro-electro-mechanical systems)**
  - → Economies of high-volume production via semiconductor industry
  - → MEMS die readily integrated with fuze electronics board---sandwich with MEMS chip
  - → Similar architecture for many weapon systems

MEMS Technology Reinvents the Mechanical S&A

Conventional Mechanical S&As

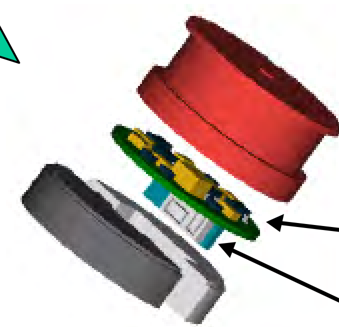


Artillery S&A



Missile S&A

Incorporate the functions of a conventional mechanical S&A in a single S&A die integrated with a fuze circuit.



Concept Fuze for OICW

Fuze Circuit

MEMS S&A die

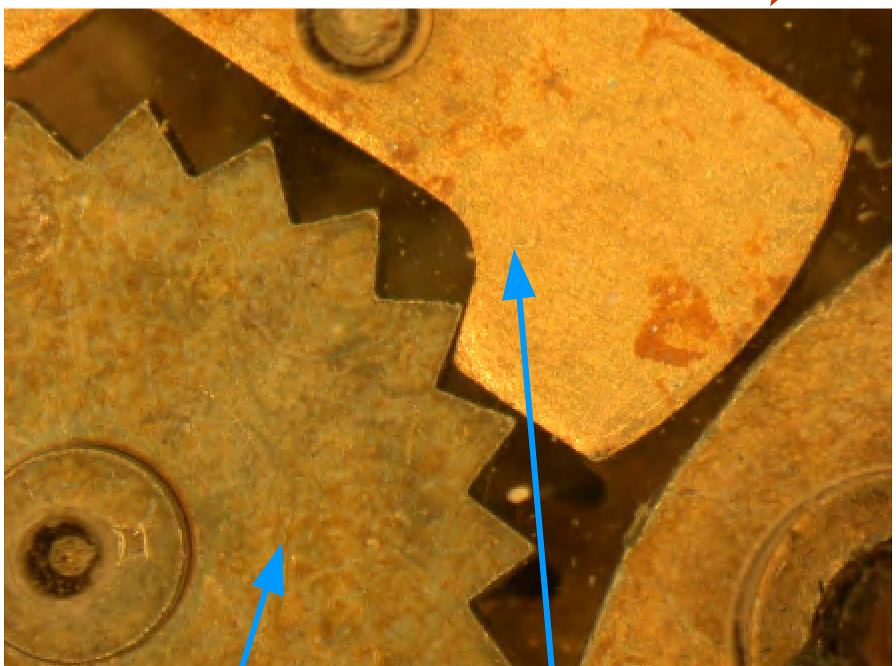
A MEMS mechanical S&A is not a “sensor” per se. Rather, its components intrinsically combine both sense and actuate functions in a single unpowered chip.

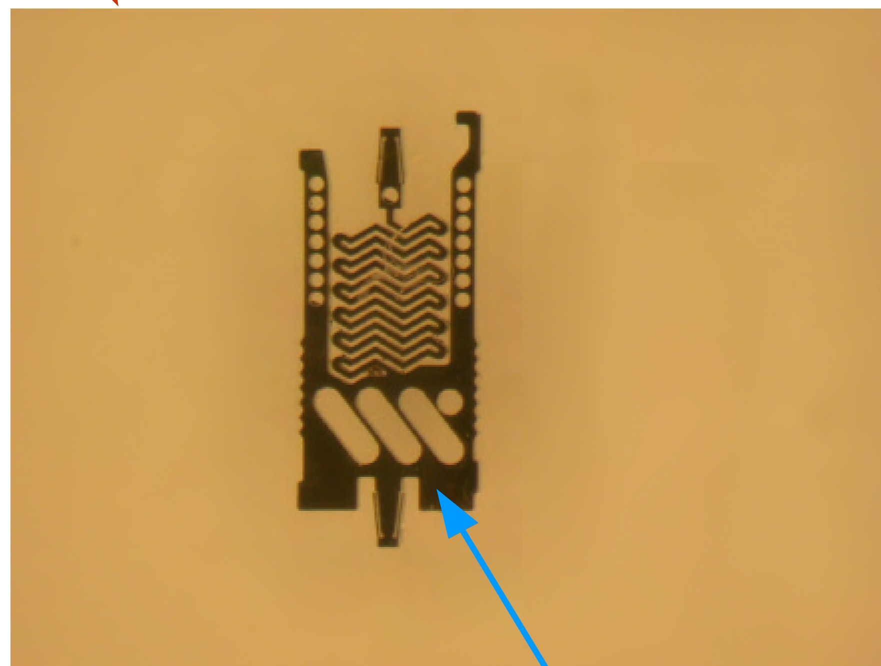
MEMS – “In a Nutshell”

Same Scale

OLD WAY

MEMS WAY

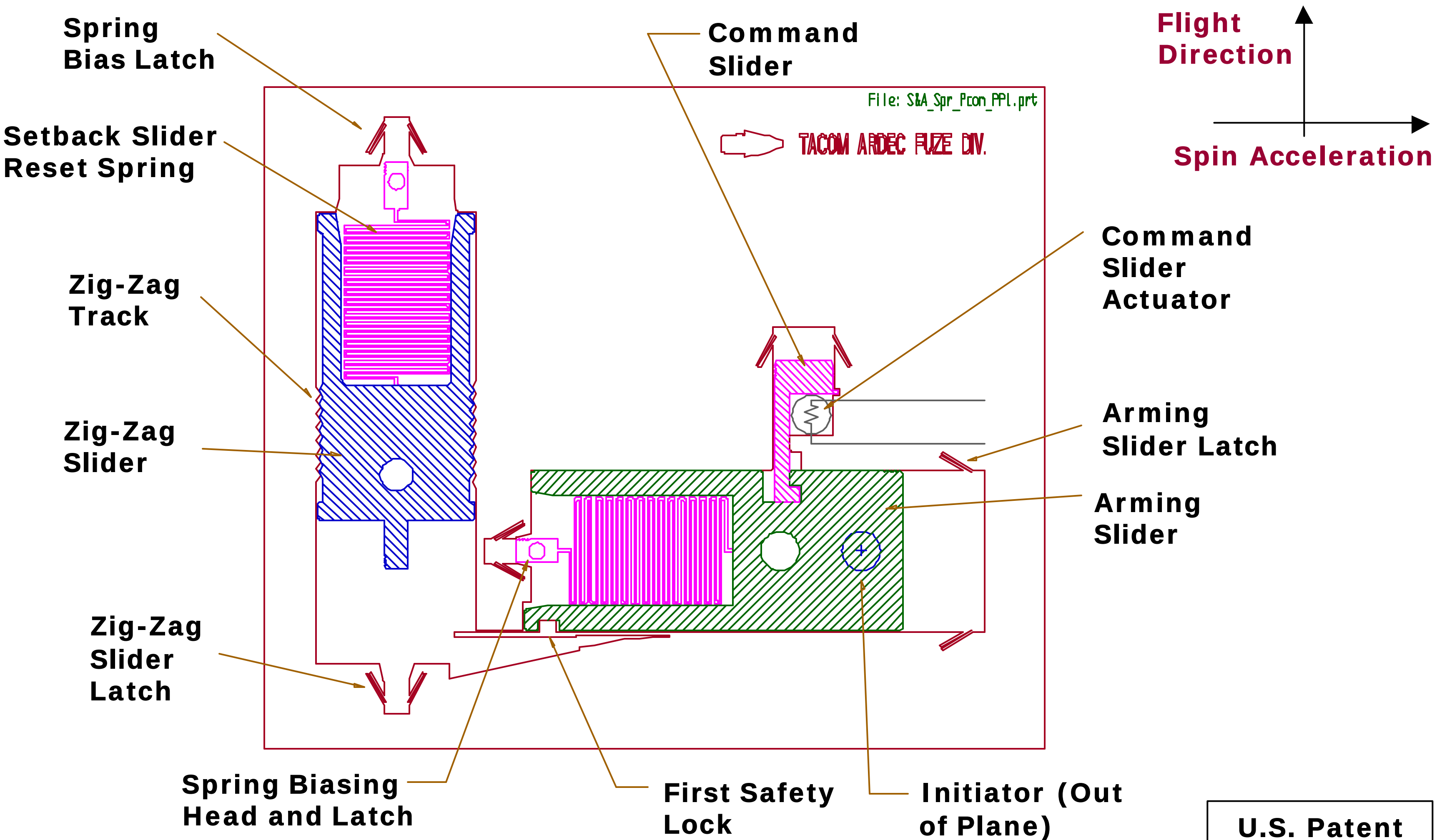




Gear Drive and Pallet

Zig-Zag Slider

Ultra-Miniature Monolithic Mechanical S&A

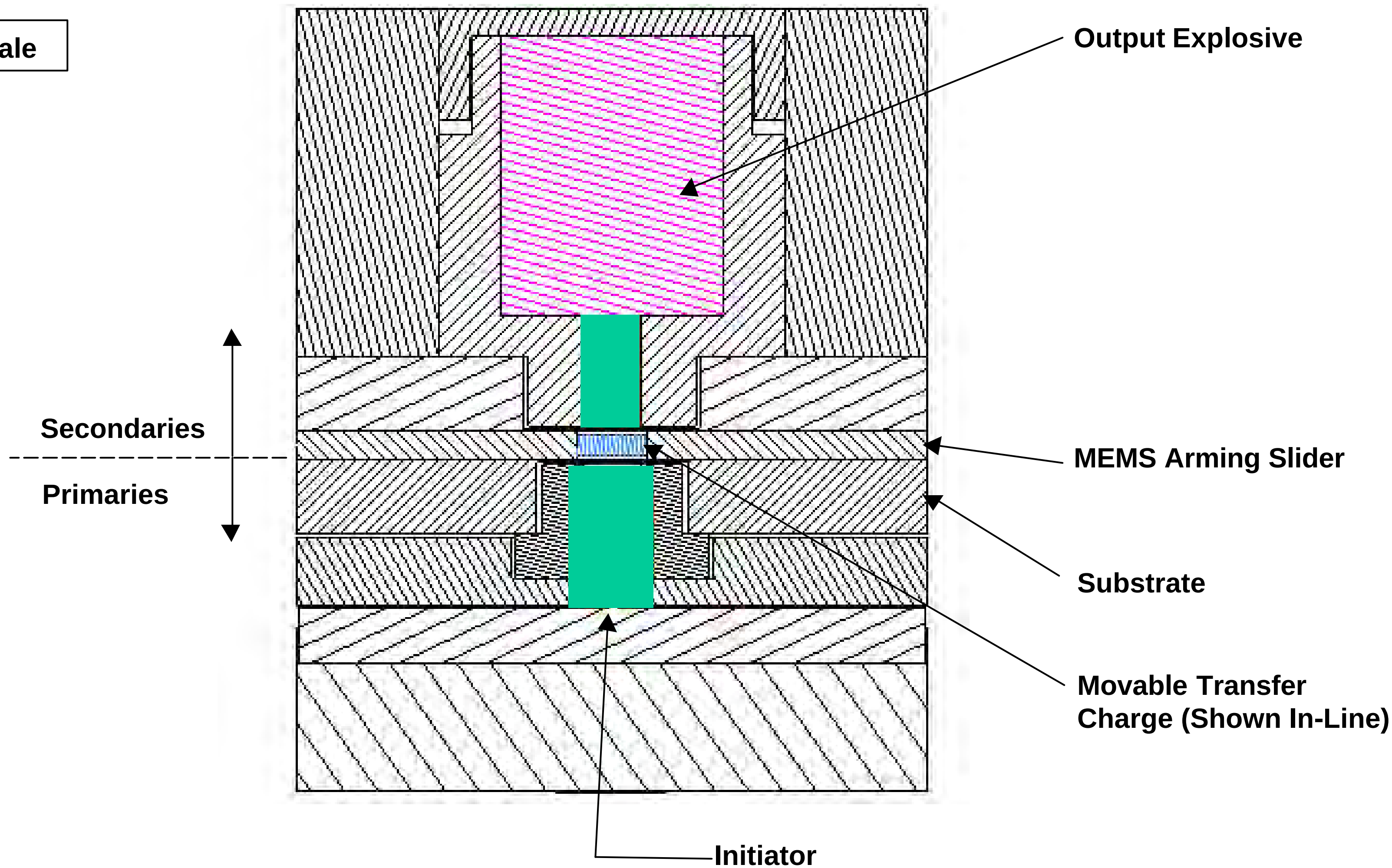


U.S. Patent 6,167,809

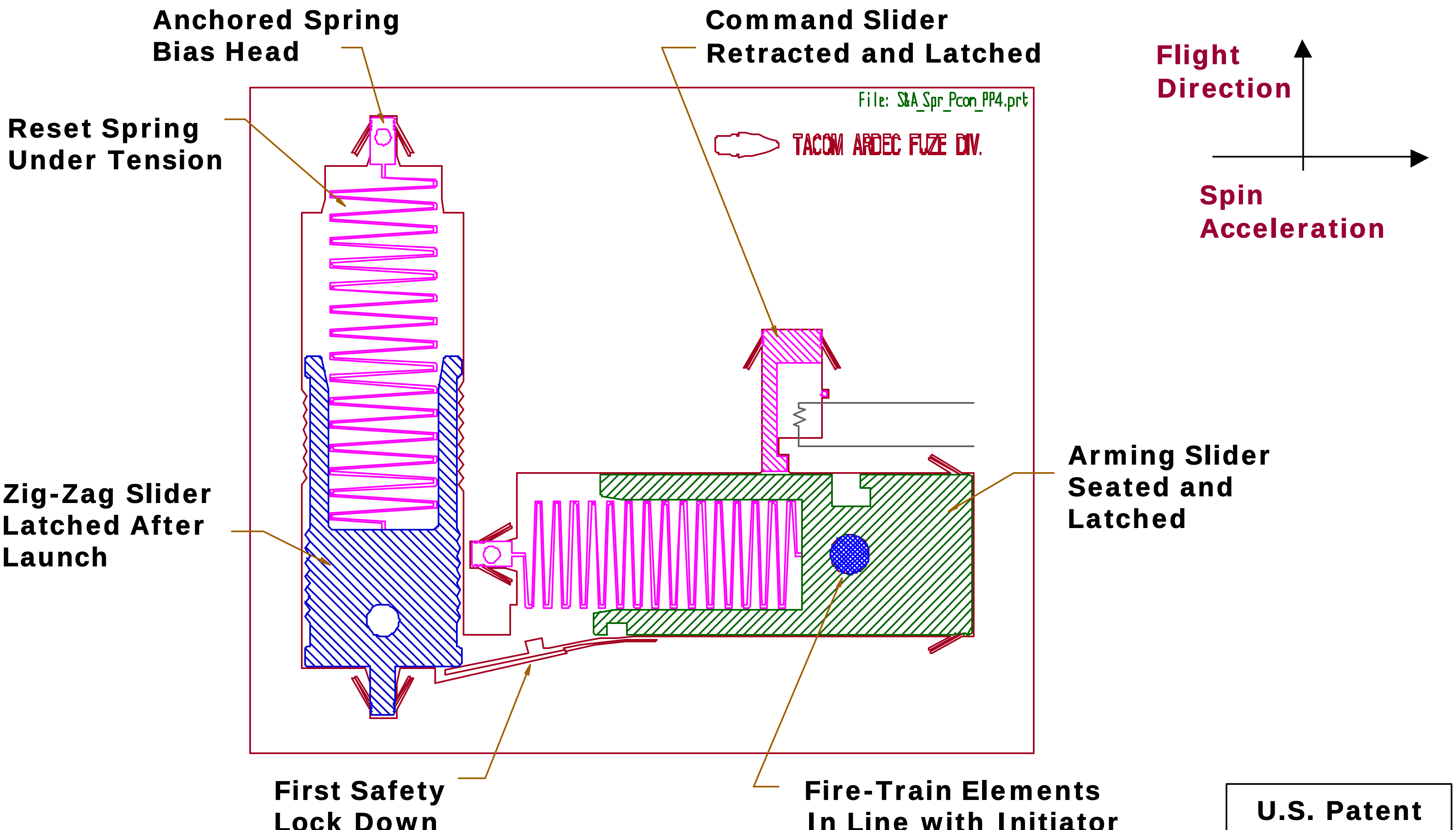
Committed To Excellence

MEMS-Enabled Firetrain per MIL-STD-1316

Not to Scale



Components in Armed Position

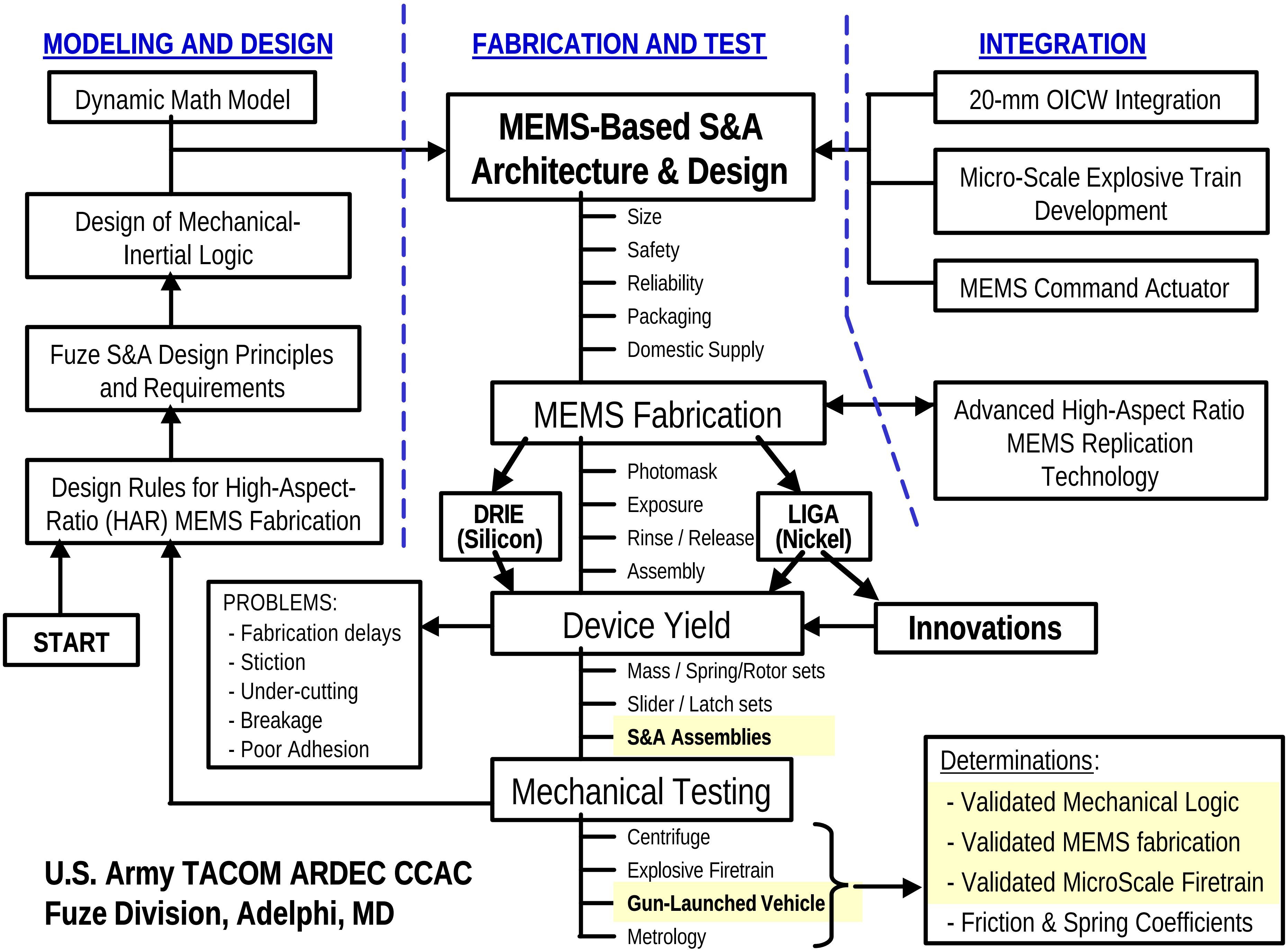


U.S. Patent 6,167,809

Committed To Excellence

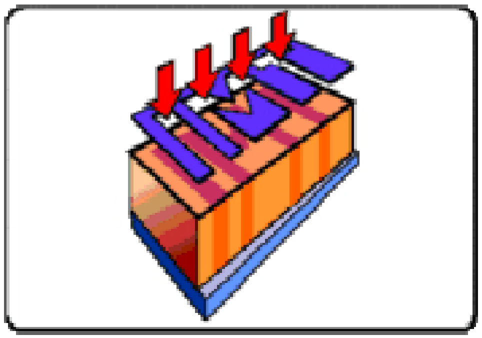
Technical Teamwork

- **Program Coordination:**
  - → Technical Lead, TACOM ARDEC CCAC Fuze Division
  - → Program Sponsor, JSSAP (OICW System Enhancements STO)
- **MEMS S&A Device**
  - → Concept, Analysis, and Design: TACOM ARDEC CCAC Fuze Division
  - → MEMS Fabrication, CNRI MEMS Exchange, Reston, VA
- **Micro-scale Firetrain**
  - → Firetrain development, NAWC-China Lake
  - → Firetrain producibility, TACOM ARDEC WECAC
- **Flight Test Support**
  - → 40-mm Grenade (MK19 LMG platform): ARL Blossom Point Test Facility
  - → 20-mm OICW Projectile (Mann barrel): Alliant Techsystems

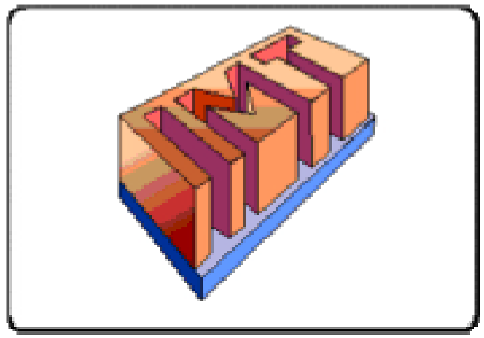

MODELING AND DESIGN
FABRICATION AND TEST
INTEGRATION
Dynamic Math Model
MEMS-Based S&A Architecture & Design
20-mm OICW Integration
Micro-Scale Explosive Train Development
MEMS Command Actuator
Design of Mechanical-Inertial Logic
Size
Safety
Reliability
Packaging
Domestic Supply
Fuze S&A Design Principles and Requirements
MEMS Fabrication
Advanced High-Aspect Ratio MEMS Replication Technology
Design Rules for High-Aspect-Ratio (HAR) MEMS Fabrication
DRIE (Silicon)
Photomask
Exposure
Rinse / Release
Assembly
LIGA (Nickel)
START
PROBLEMS:
- Fabrication delays
- Stiction
- Under-cutting
- Breakage
- Poor Adhesion
Device Yield
Innovations
Mass / Spring/Rotor sets
Slider / Latch sets
S&A Assemblies
Mechanical Testing
Determinations:
- Validated Mechanical Logic
- Validated MEMS fabrication
- Validated MicroScale Firetrain
- Friction & Spring Coefficients
Centrifuge
Explosive Firetrain
Gun-Launched Vehicle
Metrology
U.S. Army TACOM ARDEC CCAC
Fuze Division, Adelphi, MD

Materials and Micromachining for MEMS

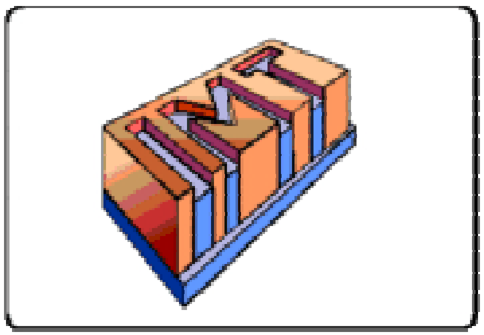
Lithograph (LIGA) Process



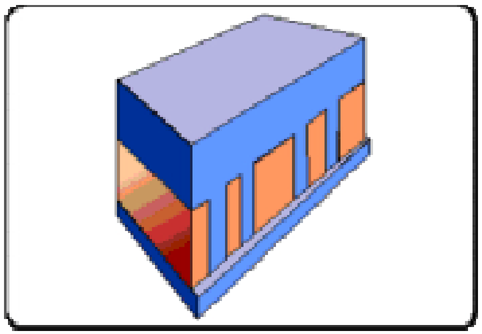
1 Exposure



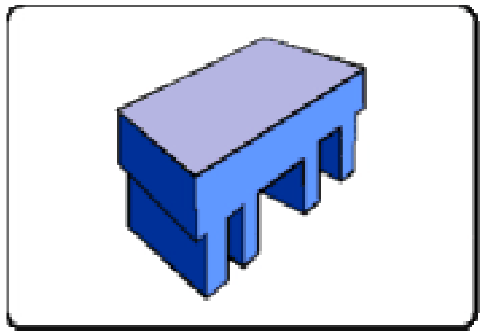
2 Development



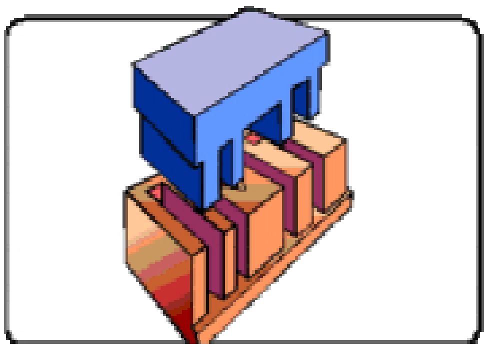
3 Electroforming



4 Fabrication of molding tool



5 Molding tool



6 Molding

"MEMS" Technology – Define Terms!

MEMS ≠ MEMS

PROCESSES

LIGA
RIE and DRIE
SU-8
Bulk Etching
iMEMS
Wafer bonding
HAR and LAR
Surface Etching

Sensors
Actuators

Active
Passive

MATERIALS

Silicon
Nickel
SiC
Ceramic
Poly-silicon
Piezoelectric Film
Shape-memory alloy

PHYSICAL PRINCIPLES

Inertial
Thermal
Electromagnetic
Piezoelectric
Fluidic
Chemical
Electrostatic
Optical

SIGNATURES

Acceleration
Force
Rate
Flow
Chemical
Pressure

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Status/Issues One Year Ago (April 2001)

One Year Ago (May 2001)

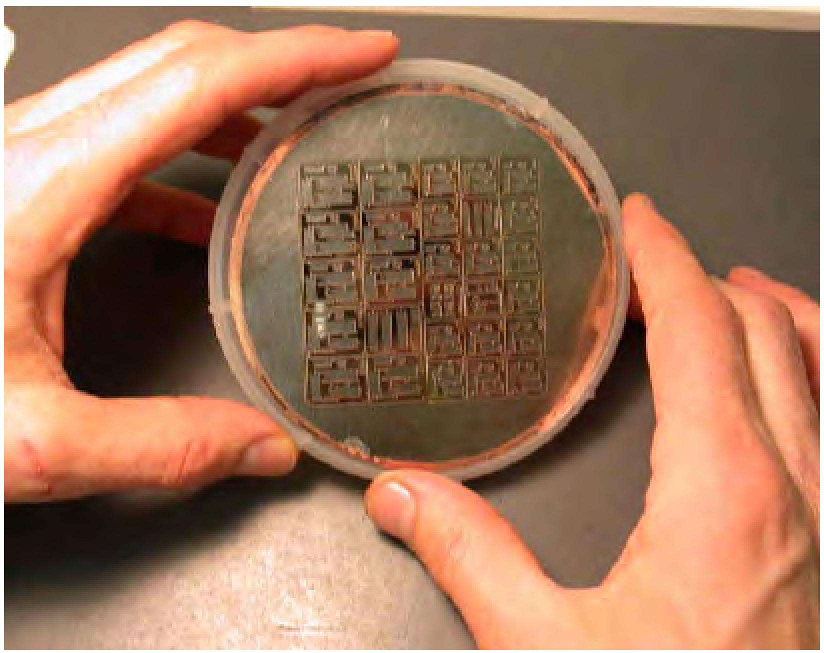
- **Demonstrated components/assemblies for 3-slider mechanical logic**
  - → springs, sliders, masses, locks, latches
- **Dearth of MEMS parts**
  - → Fabrication cycle times were 6 to 12 months
  - → Silicon process "yield" was low, approximately 20%
  - → Moving from silicon to nickel technology
- **Testing:**
  - → Lacked hardware to do scheduled gun launch demonstration
- **Parallel development of micro-scale firetrain in laboratory:** Proceeding well

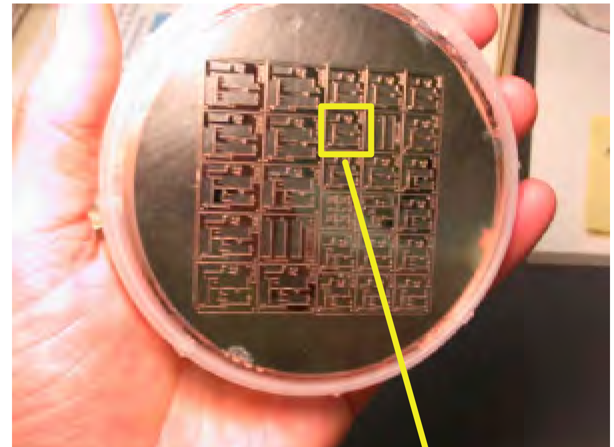
This Year (May 2002)

- **Lots of parts**
- **Flight test results**
- **Firetrain development is keeping pace**

Fabrication –MEMS Substrates

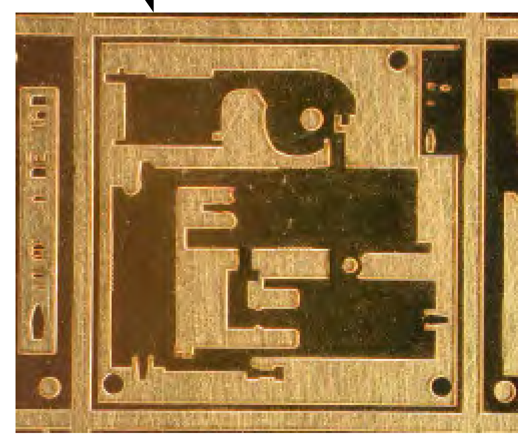
- LIGA high-aspect-ratio MEMS fab
- 10 x 10-mm substrate dies
- About 36 dies fit on a 4” wafer



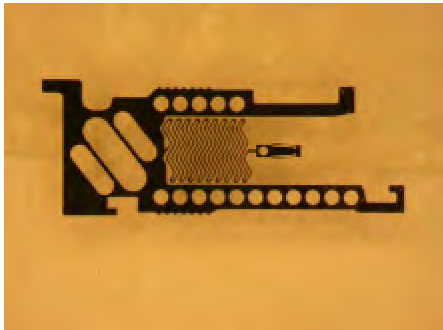


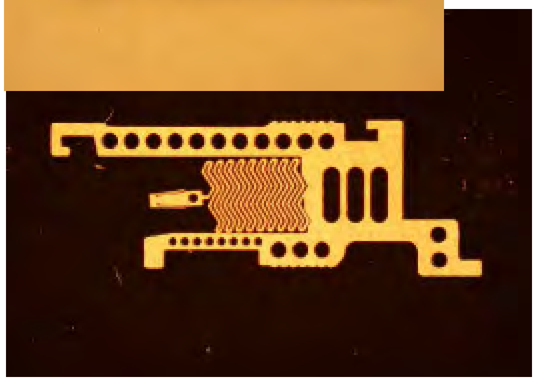
‘Frame’ die

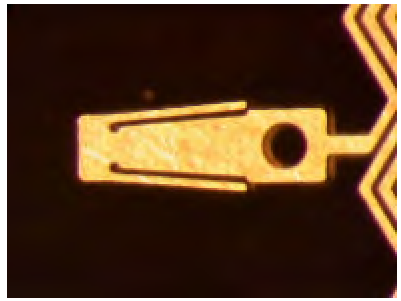
LIGA (nickel) micro-parts are micro-assembled into LIGA-formed “frames”

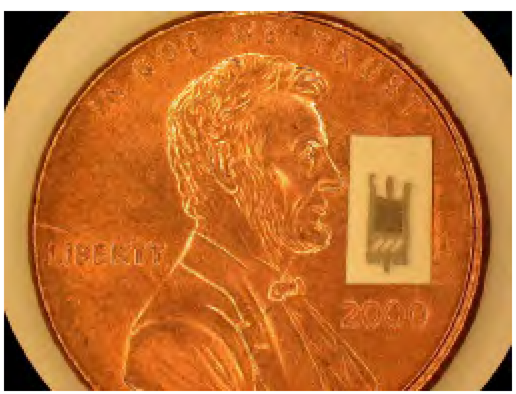


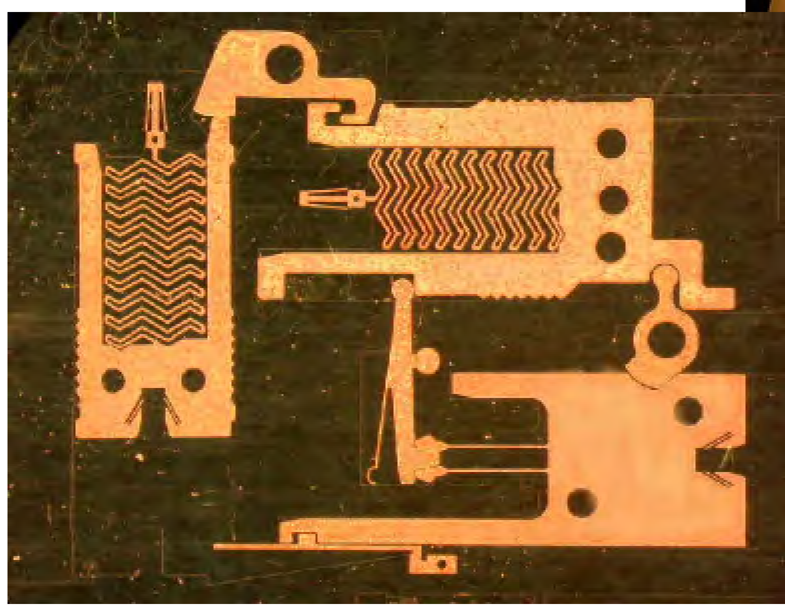
Fabrication – Parts and Assembly











U.S. Patents

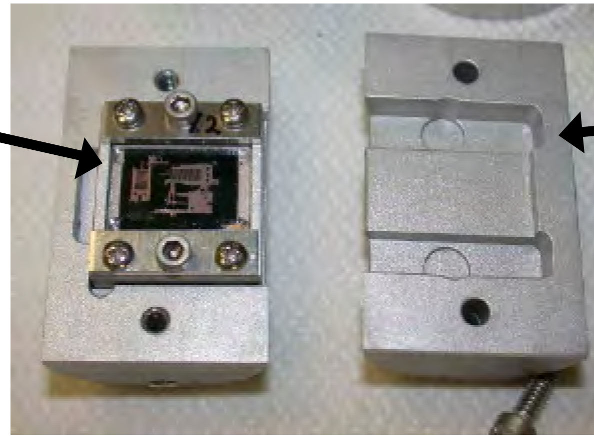
5,705,767

6,167,809

6,321,654

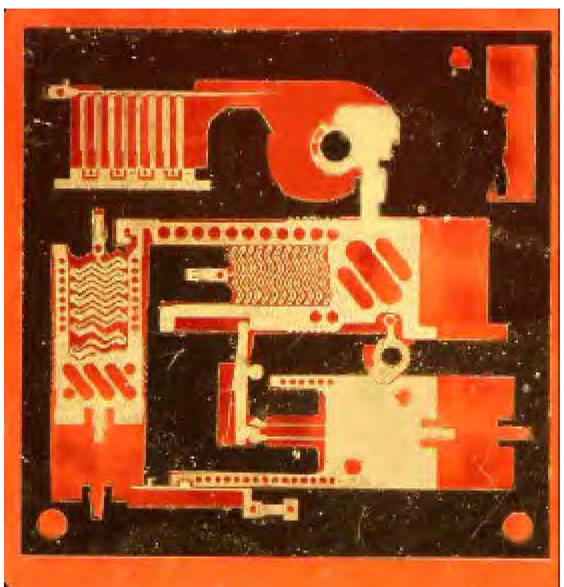
Assembly for Test

Die Carrier

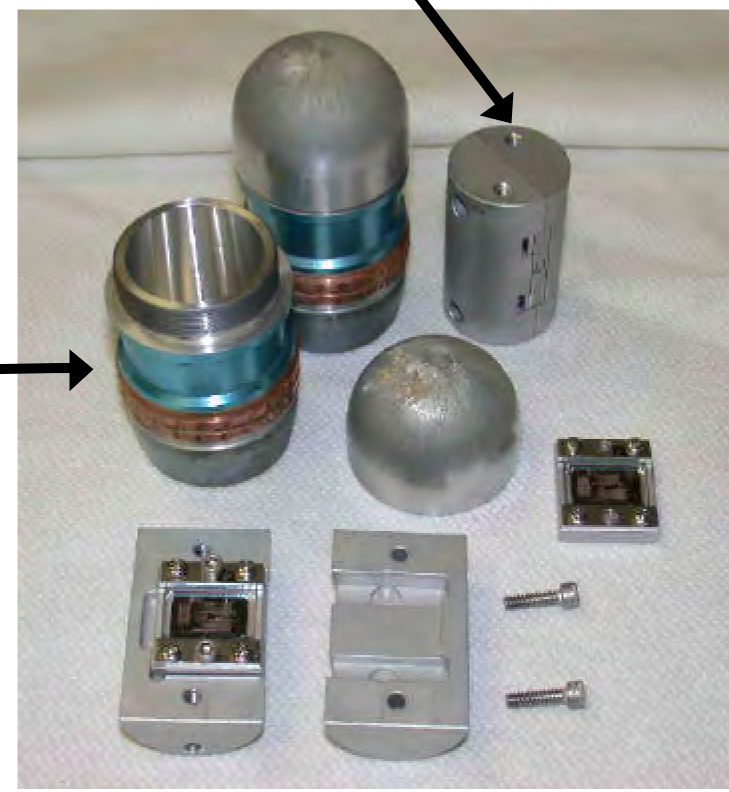


Clamshell Module

S&A Die, 10 x 10 mm



40-mm Grenade



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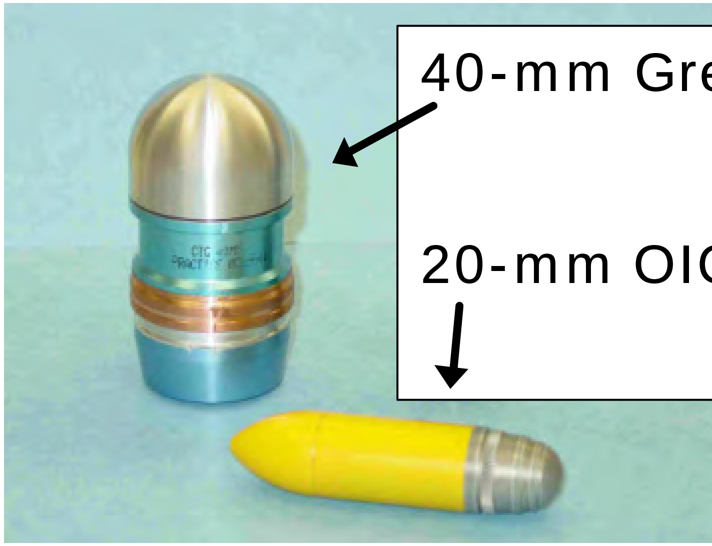
April 2002
Ballistic Test of S&A, 40-mm Grenade



<u>Flight Test, 02 April 2002</u>

- **ARL Blossom Point Test Range**
- **Mk19 LMG, 40-mm grenade**
  - **42 kGs Setback (peak)**
  - **200 RPS Spin**
- **12 inert S&A Assemblies Fired***
- **Sawdust catch box and recovery**

*** Command actuator not included**

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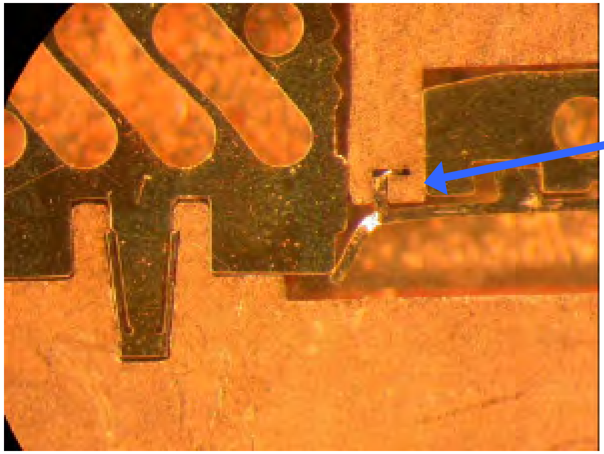
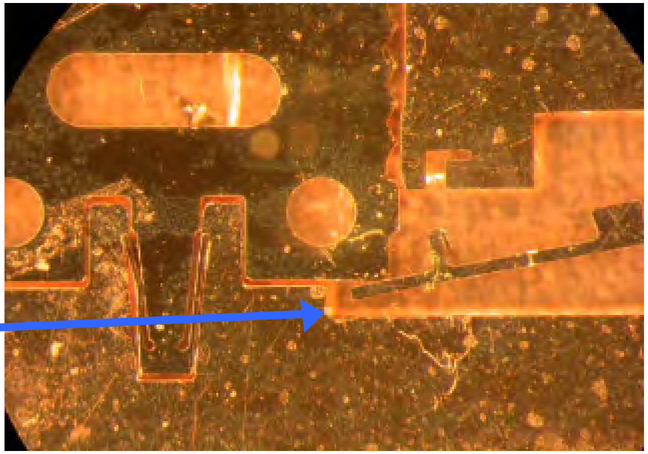
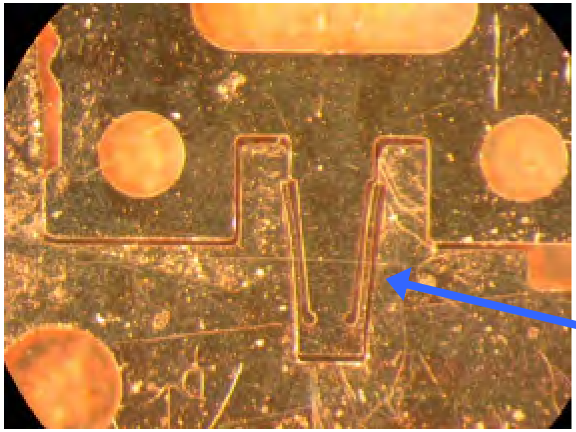
Results continued, Mk19 Flight Test



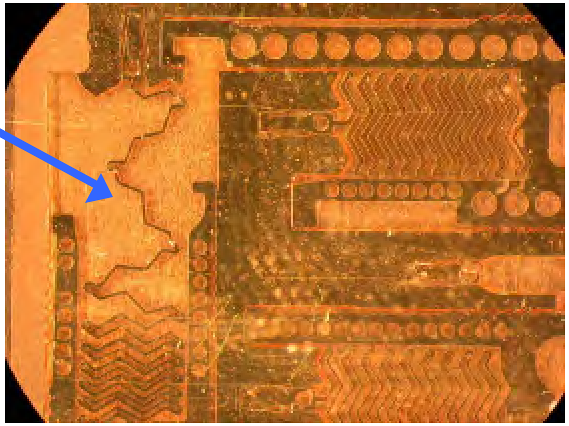
<u>Failure Analysis:</u> shear tab did not release and lock lever bent.



<u>Solution</u>: strengthen lock lever and re-engineer sheer tab



Slider Locks: some did not hold, make design more robust



Setback Slider Spring Deploys OK

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Results from Mk19 Test

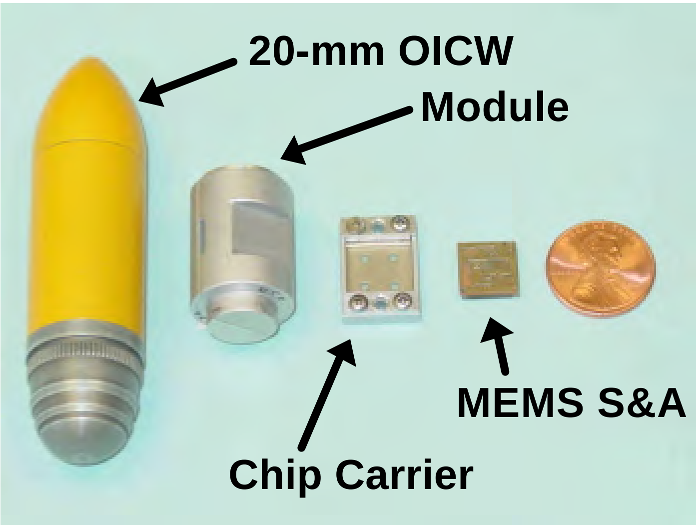
Summary:

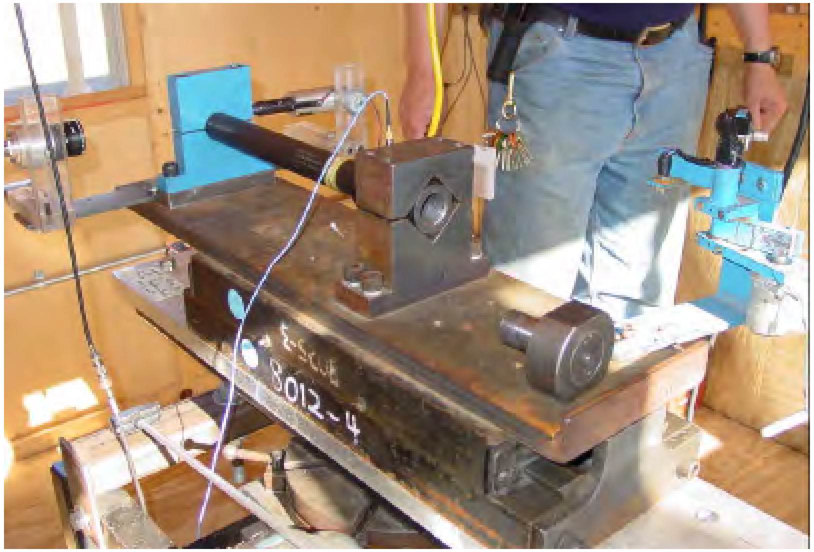
- **Eight of twelve S&As armed correctly**
- **Three S&As did not arm because setback lock shear tab was too strong**
  - → **Lock lever was too weak, failed in bending**
  - → **Setback slider provided plenty of force!**
- **One S&A did not arm, reason not yet known**

Findings:

- **With correct shear tab and lock lever, S&A will arm**
- **If first lock not removed, arming slider remains in SAFE position!**
- **Some spring latches came loose, need to improve design**

OICW Ballistic Test of MEMS S&A





17 April 2002 Flight Test

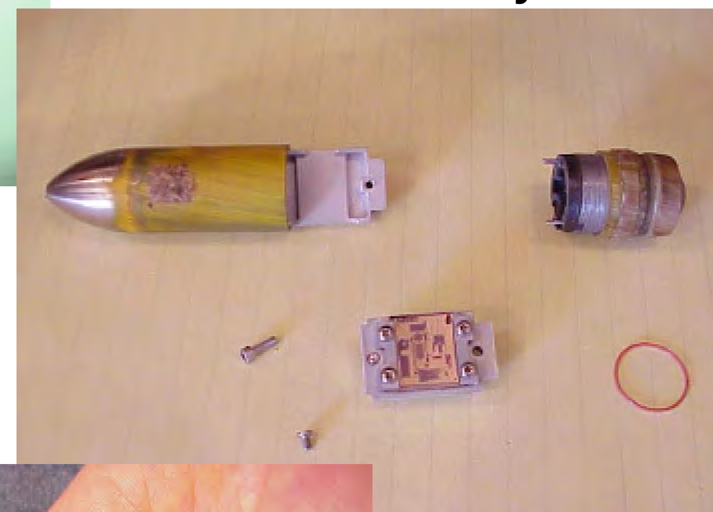
- **5 rounds* at 65 kGs Setback**
- **5 rounds* at 45 kGs Setback**
- **Mann Barrel Fixture**
- **Performed at ATK Elk River**

*** Command actuator not included**

OICW Ballistic Test of MEMS Mechanical S&A

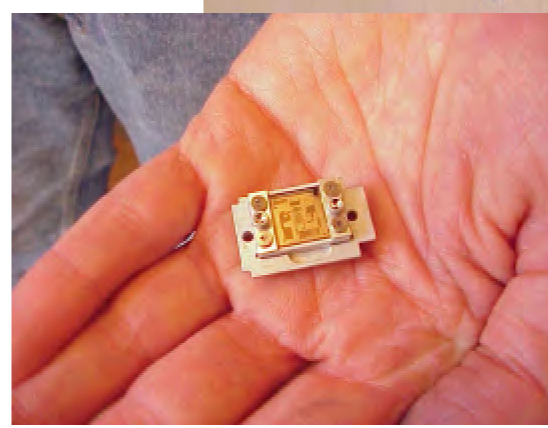
Mann Barrel
and Target

Recovered Assembly



<u>17 April 2002 Flight Test</u>

- **300-m range to target**
- **490 RPS spin**
- **Soft Catch (fiberboard)**
- **Rounds recovered**
- **Nine of nine S&As armed**



Armed S&A!

Results from OICW Flight Test

- **Of 10 shots:**
  - → Nine S&As armed correctly (but command actuator was inactive)
  - → One of the nine missed target, bounced, was recovered fully armed
  - → The one that did not arm was mis-assembled in lab (deemed a no-test)
- **Facts to notice:**
  - → No breakage: MEMS construction robust even in the 40% over-test
  - → Dynamic over-test at 65 kGs produced same results as OICW loads
  - → All latches stayed latched (retained sliders and springs as designed)
  - → Locks in the mis-assembled S&A retained arming slider in safe position

Conclusions

Findings: In OICW, MEMS S&A armed as designed, feasibility partially demonstrated

Fabrication:

- ARDEC's design and selected fabrication technology improved yield from <20% to >75%!
- MEMS foundry turnaround is now less than 6-weeks (vs. 6 months) thru MEMS Exchange
- New materials (nickel) prove robust in OICW dynamic loading

Firetrain:

- Laboratory tests validate micro-scale firetrain (MSF) at OICW sizes
- Working on 'printing' or slurry-loading of explosives in MEMS (WECAC and NAWC-CL)

Future:

- (near) 20-mm flight test of explosively-loaded S&A, ~Aug 02
- (near) Demonstration of MSF and MEMS-compatible loading techniques, ~Aug 02
- (near) Contract: MEMS fabrication solicitation on street in May 02
- (near) Contract: MEMS integration into fuze
- (farther out) Implement MEMS command actuator (1-2 years)
- (farther out) MEMS packaging and volume fabrication (3-5 years?)

END

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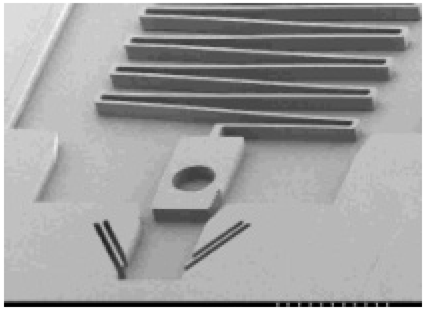
SEM of Slider, Spring, Zig-Zag Track

DSC000404crop.jpg, 59kB

4

Sprg111a.jpg, 19kB



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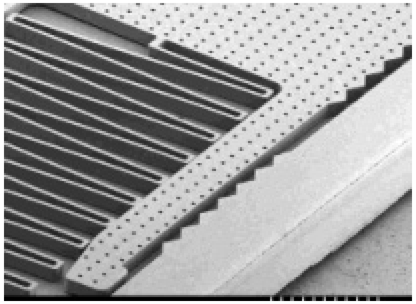

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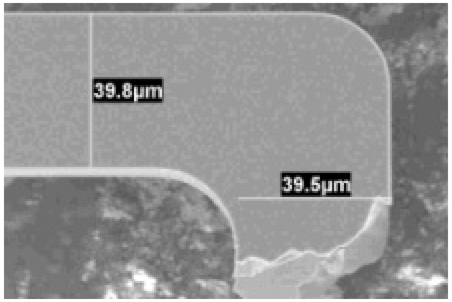

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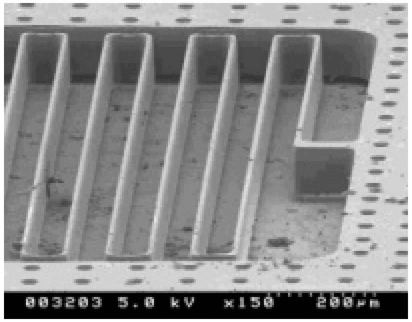

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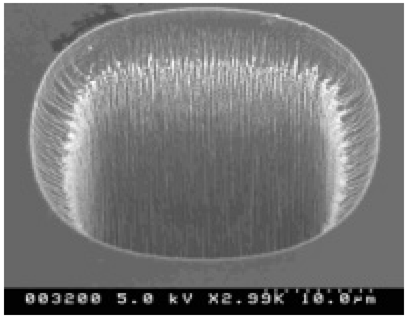

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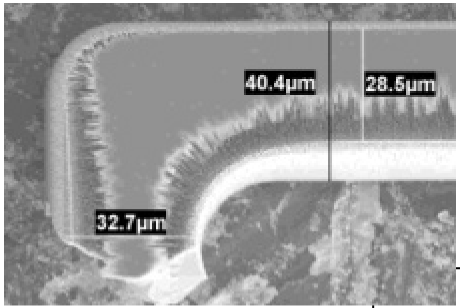

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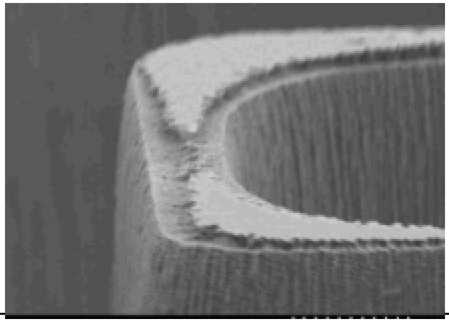

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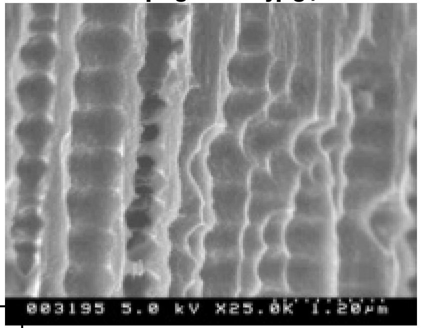
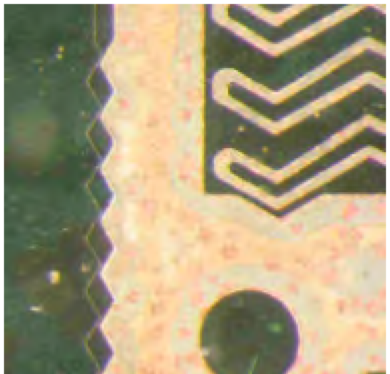


12

SEM of Slider, Spring, Zig-Zag Track

BTZigTrackSetbackCrop.jpg, 19kB



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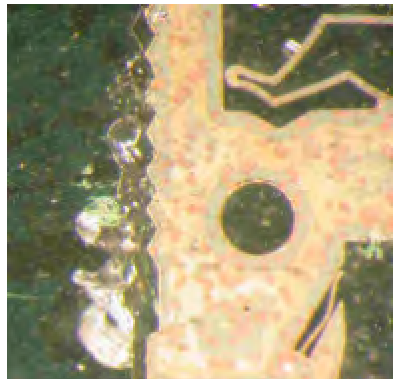

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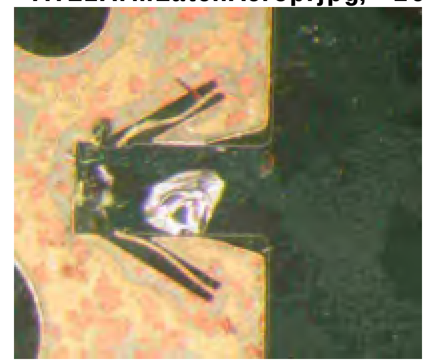

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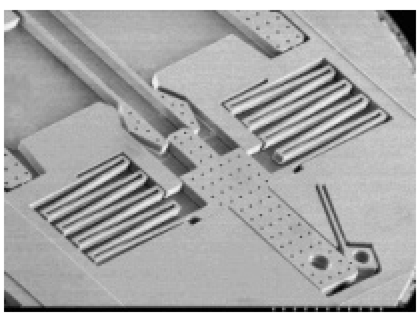

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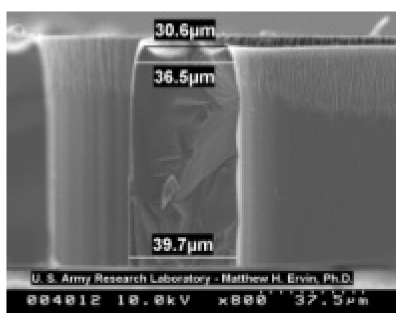
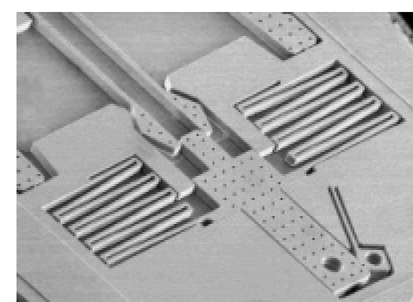


Profiles of nominal 40-mm DRIE spring, showing unintended 25% taper



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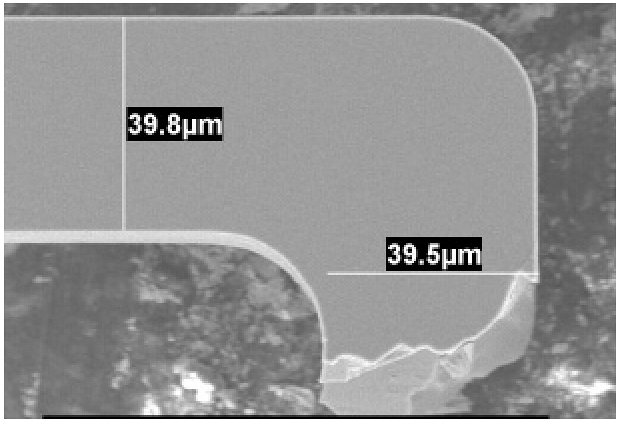
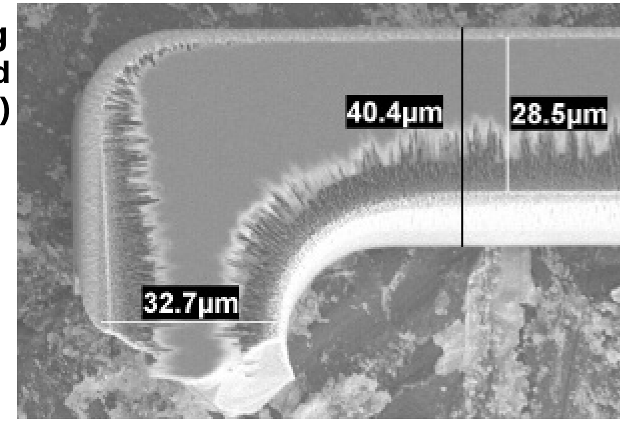
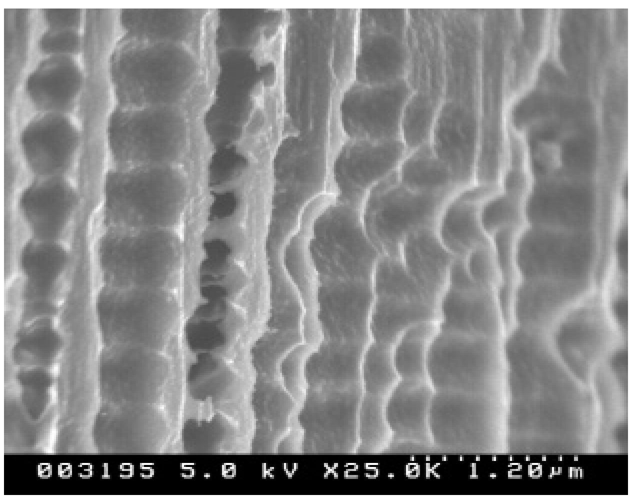
SEM Details From DRIE Fabrication



Width of nominal 40-mm DRIE spring

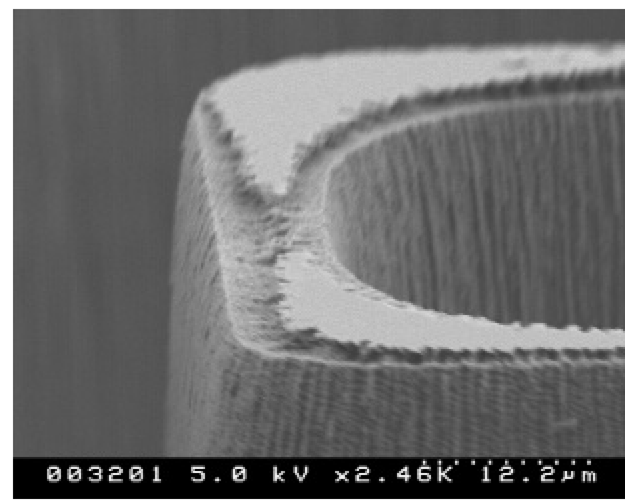
Details of undercutting of spring (unintended 25% taper)





Texture of DRIE-machined surface

Details of undercutting and release etch for 40-mm spring



TACOM

Lethality, Survivability, Mobility and
Sustainment for America's Army

National Defense Industrial Association
Small Arms Symposium

Light Fighter Lethality Seeker Projectile

May 14, 2002

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This Presentation is Approved for Public Release

Outline

Munitions IPT
Program Objective
Performance Metrics
Concept Description
Operation
Trajectory
In-House Design Effort
In-House Wind Tunnel Model
Wind Tunnel Testing
Preliminary Test Results
Adaptive Material
Properties of Adaptive Materials
Adaptive Material Wind Tunnel Model
Properties of this Wind Tunnel Model
Testing in Wind Tunnel
Laser Light Deflection Experiment
High Speed Video Experiment
Preliminary Test Results
Conclusions
Future Plans

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Light Fighter Lethality Participants

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STO Management

Kori Spiegel
STO Manager

User
Fire Control
Weapon
Management

Lucian Sadowski
Munitions IPT

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John Whiteside
Mike Amoruso
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Tomas Cincotta
Jay Vizgaitis
Sam Sweatt
Dave Randall
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Ray Trohanowsky
John Resotka
Dan Cheney
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Adaptive Aerostructures Laboratory

Stephen Small, JSSAP
Los Alamos National Lab
Larry Hull
Warhead Study

Bill Cadwallender
Animation
Software Engineering

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Light Fighter Lethality

Program Objective: Define, Develop, and Demonstrate an Ultra-Lightweight Lethality System that:

- Dramatically Reduces Warfighter Weight
- Increased Lethality for the Individual Soldier
- Maximizes Operational Utility and Survivability
- Operates In All Environments
- Tailorable To Mission Specific Roles

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PERFORMANCE METRICS:

	Threshold	**Goal**
Individual System Weight		
- Less Than	10 lbs	5 lbs
Probability of Incapacitation		
- Greater Than 0.5 @	300 M	500 M
Ammunition Weight		
- Less Than	0.5 lbs	0.25 lbs

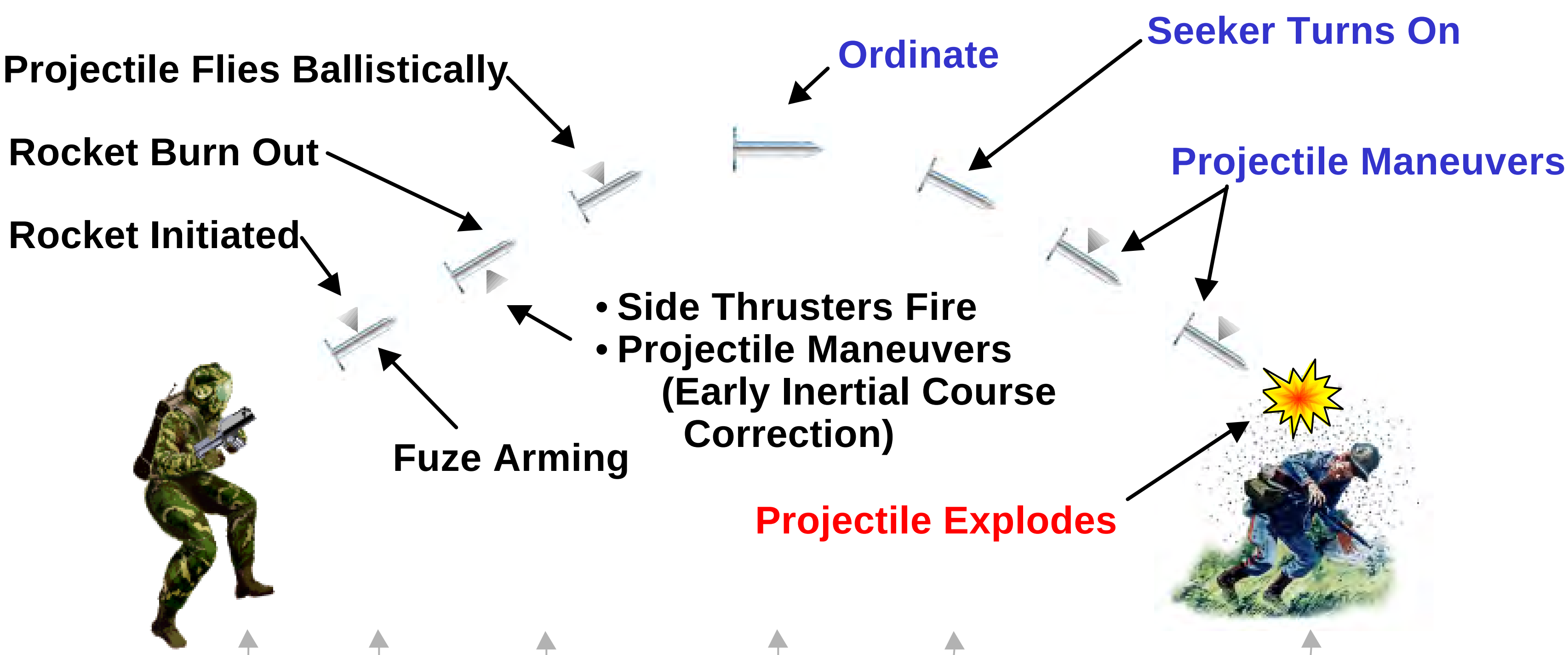
Seeker Projectile System Concept Description

- Concept Based on Projectile knowing Target Location at Launch
- Projectile knows how far it is off its initial trajectory during flight
- In Flight, the Seeker can detect/recognize the Target, Stationary or Moving

Operation

- Target Image, Range, and Azimuth Given To Projectile At Launch
- Projectile Flies Autonomously to Target Coordinates
- Initial Stages of Projectile Flight:
    - Projectile Determines Orientation, Position, and Course Corrections Required Using On-Board Inertial Reference Measuring Device
    - Activates Maneuver Mechanism as Required
- Projectile Approaching Target Coordinates:
    - Activates On-Board Seeker
    - Seeker Locates Target Signature
    - Projectile Maneuvers and Engages Target

500m Trajectory Example



Range (meters)	0	29	148	250	296	500
Velocity (m/s)	60	58	180	159	150	117
Time of Flight (sec)	0	0.5	1.5	2.1	2.4	4
Altitude (meters)	0	5	13	15	14	0

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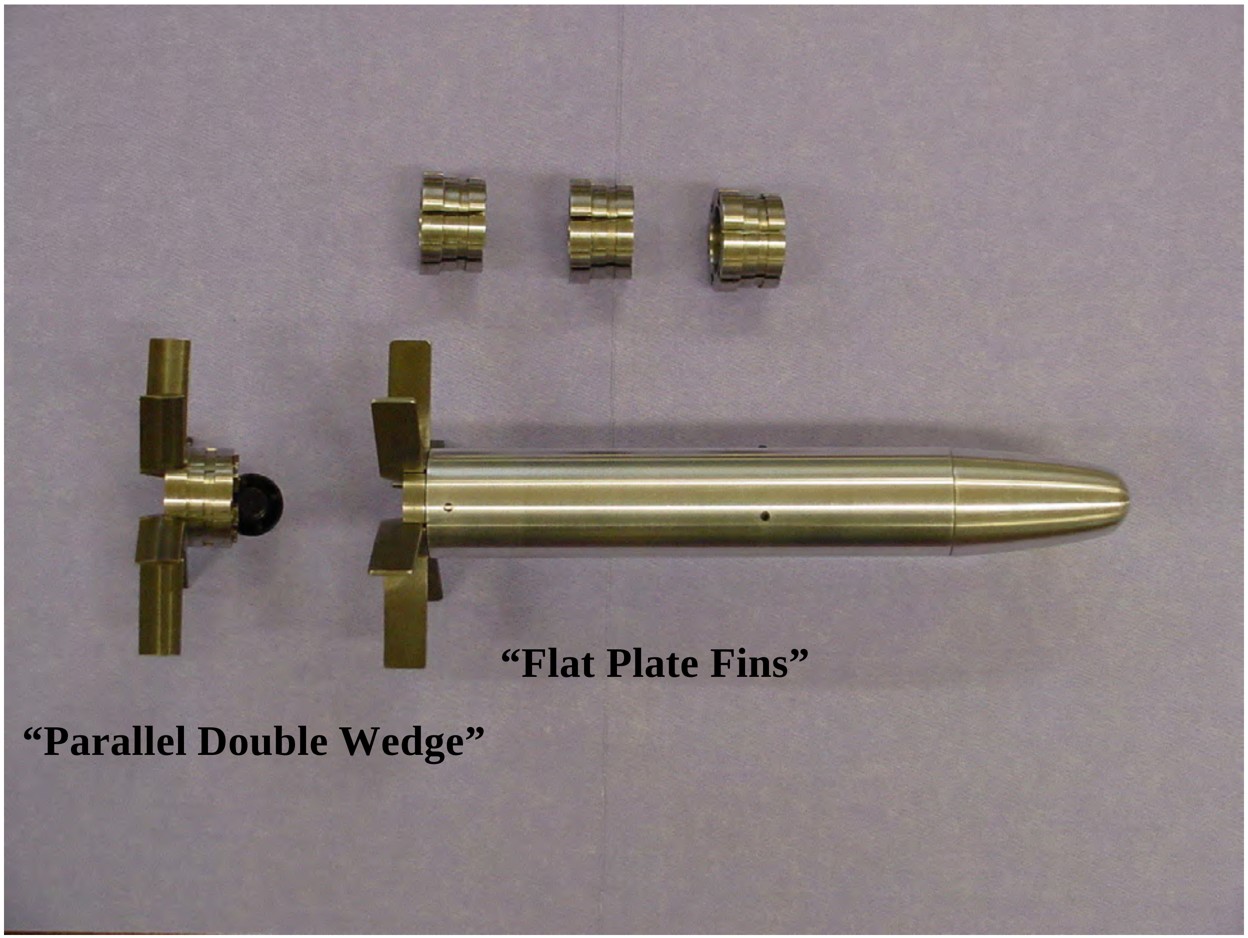
In-House LFL Seeker Projectile Wind Tunnel Model



In-House LFL Seeker Projectile
Wind Tunnel Model in the Chamber

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Wind Tunnel Test Plan

The Light Fighter Seeker Projectile is Fin Stabilized - Six Fins
Length is 155 mm (6.1 inches), 25mm in diameter, weight is 240 grams (.53 lbs.)
Model is 25% larger than the current LFL Seeker Projectile Design
Testing was conducted in the TACOM-ARDEC Picatinny Wind Tunnel Facility
One Ogive (nose), One Body and
Three Different Fin Designs
- “Flat Plate”, “Parallel Double Wedge”, and “Airplane Wing” Fin Designs

Three different Fin Cant Angles
- 0 Degrees, 2 Degrees, and 4 Degrees

Angles of Attack
- 0 Degrees up to 20 Degrees.

Mach Numbers
- .1, .2, .3, .4, and .56

Fin Roll Angles
- 0, 7, 15, 25 Degrees

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Preliminary Wind Tunnel Results
In-House Design

	Drag (alpha = 0 Degrees)	Static Stability (calibers / %)
"Flat Plate" Fin Mach Number 0.56	0.54	1.77 / 28
"Parallel Double Wedge" Fin Mach Number 0.56	0.28	1.46 / 23
"Airplane Wing" Fin Mach Number 0.56	0.27	1.80 / 29

Static Stability is in % of body length which is 6 .228 calibers
Center of Gravity location is 3.6 calibers from the nose

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What is an Adaptive Material ?

A material which undergoes a change in mechanical, thermal, optical, chemical, electrical, or magnetic properties as a function of a given stimulus*

Why use Adaptive Material ?

- Adaptive materials can be used as Flight Control Actuators
- Adaptive materials can be configured into Canards or Fins
- Adaptive Materials only require electrical energy
- No more motors and gears, saving weight and space

* Fundamentals of Adaptive/Smart Aerostructures Short Course by Dr. Ron Barrett, Auburn University, AL

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Lethality, Survivability, Mobility and Sustainment for America's Army

Which Adaptive Material is used in the Model?

The actuators were made from tape-cast PZT-5A Piezoceramic Sheets
Nomenclature - Lead-Zirconate Titanate Micro-Flex Actuator*

How is Auburn University Involved?

- Leaders in the field of Adaptive Materials and applications to Aerostructures
- Successful Phase 1 SBIR with Lutronix, Auburn Univ. was the sub-contractor
  - Title of the FY 2000 SBIR - Cal. 50 Smart Bullet
    - Application of this technology as a maneuver mechanism
- Purchase Order with Barrett Aerospace Technologies in FY 2001
  - Fabricate an Adaptive Material Wind Tunnel Model
    - Configuration of a version of the LFL Seeker Projectile

* Fundamentals of Adaptive/Smart Aerostructures Short Course by Dr. Ron Barrett, Auburn University, AL

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Adaptive Material Wind Tunnel Model Properties

Length of the model - 227 mm - 9 inches
Diameter of the model - 25 mm - 1 inch
Location of fins from ogive - 169 mm- 6.6 inches
Fin Semi-Span - 25 mm - 1 inches
Fin Chord - 10 mm - .4 inches
Thickness of Fin - 1 mm - 0.04 inches
Two fixed fins - carbon fiber
Two fins - Adaptive Material - steel spar
Maximum Fin Deflection - 2.6 Degrees at 140 Volts
Actuation Frequencies - 0 to 260 Hz, resonance at 160 Hz

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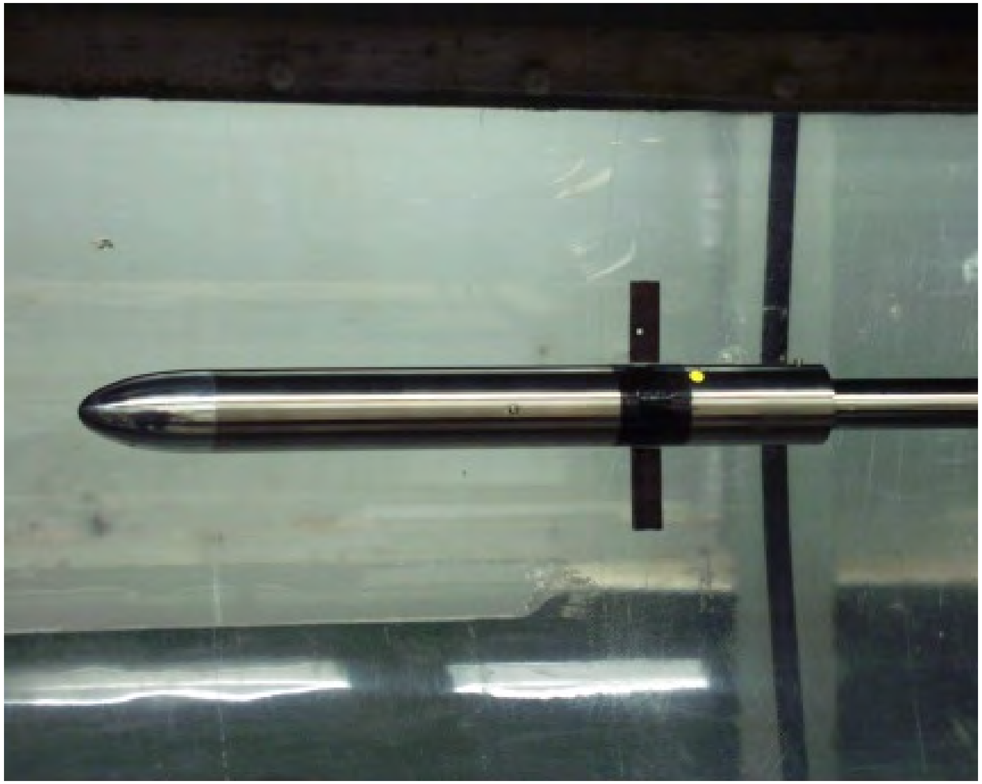
Adaptive Material Wind Tunnel Model



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Adaptive Material Wind Tunnel Model

First Wind Tunnel Test of Adaptive Material for Small Arms Ammunition

Place Model in the Wind Tunnel

Observe the Angular Fin Movement

Wind Off and Wind On

Documented Motion of the Fin

- Laser Light Deflection Experiment
- High Speed Video Experiment

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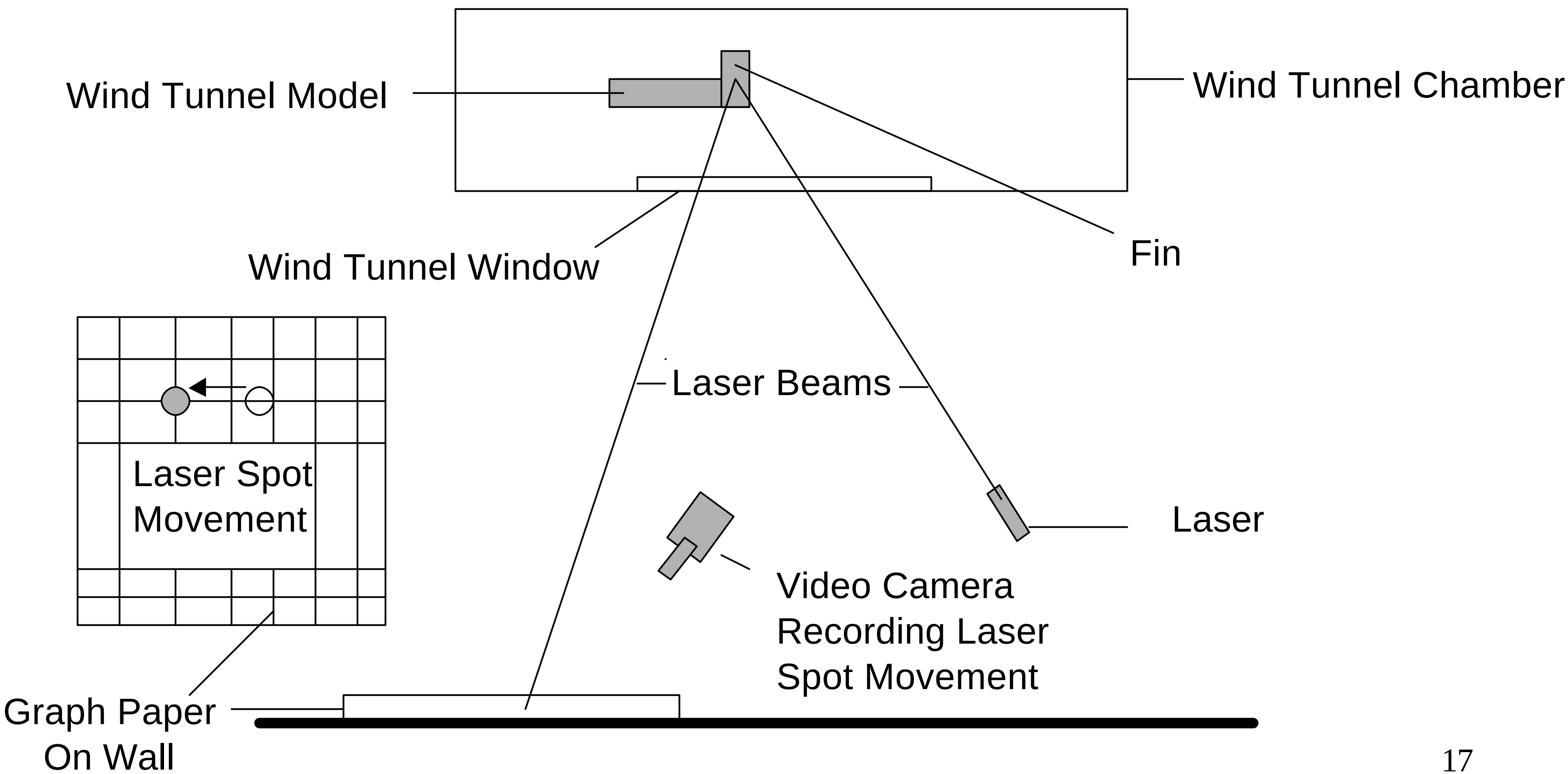
Adaptive Material Wind Tunnel Model Laser Light Deflection Experiment



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Adaptive Material Wind Tunnel Model Preliminary Test Results

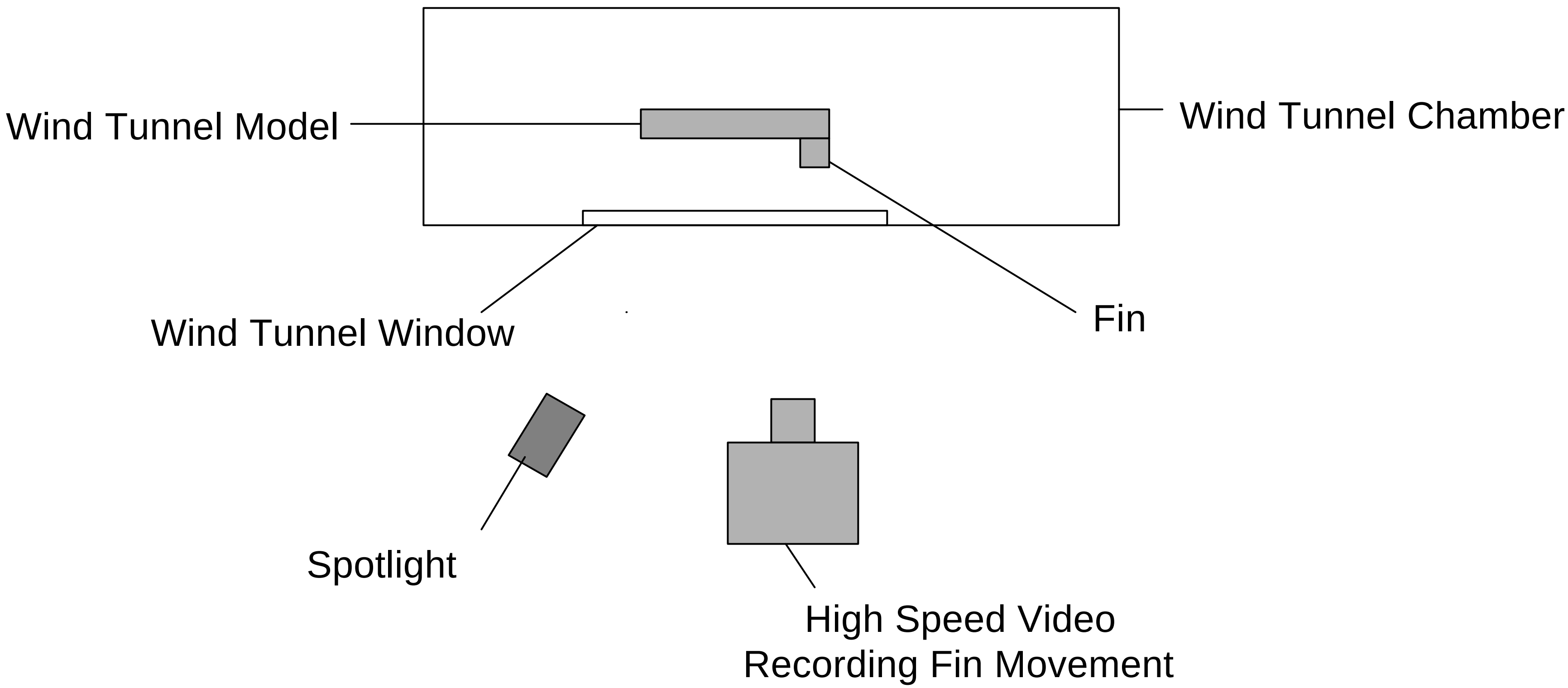
Mach Numbers 0.0, 0.1, 0.2, 0.3, 0.4, and 0.49

Angle of Attack - 0 Degrees

Laser Light Deflection Experiment

- Dynamic Mode - 1 Hz
  - Total angular deflection approximately 1.9 degrees
    - No difference between Wind Off or Wind On
- Static Mode - 0 degrees, 0.8 Degrees, 2.0 Degrees
  - Total angular deflection
    - No difference between Wind On or Off
  - Mid position - Mach 0.4
    - Difference of 0.5 degrees between Wind On or Off

Adaptive Material Wind Tunnel Model High Speed Video Experiment



Adaptive Material Wind Tunnel Model Preliminary Test Results

High Speed Video Experiment - Initial Observations

- Rotated Model 90 degrees to view moving fin edge on.
  - Dynamic Mode - Total Angular Deflection - 3.6 Degrees
    - Mach Numbers - 0.0, 0.3, 0.4 - 1 Hz
      - No difference between Wind Off and Wind On
    - Mach Number - 0.5
      - Dynamic Mode - 20, 30, 40, 60, 100, and 125 Hz
        - No difference in fin deflection, Wind Off and Wind On
    - Noticed Fin did move downward with Wind On

Adaptive Material Wind Tunnel Model Summary

Adaptive Material Fin Function:

- Reliable, Repeatable, Predictable
- Capable of Fast Response times approaching Explosive Squibs
- Considering Adaptive Material Fins as a Complimentary Maneuver Mechanism for the LFL Seeker Projectile

Adaptive Materials have application to Small Arms Ammunition

Conclusions

- Wind Tunnel Model testing was a success!
- The In-House Projectile Design is Stable!
- Adaptive Material Wind Tunnel Model testing was a success!
- Adaptive Materials are Capable of Very Fast Response times Approaching Explosive Squibs
- Considering Adaptive Material Fins as a Complimentary Maneuver Mechanism for the LFL Seeker Projectile

A Light Fighter Lethality Projectile is Feasible!

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Future Plans

Broad Agency Announcement:

Two contracts were awarded on May 3, 2002 !

- General Dynamics Ordnance and Tactical Systems (Aerospace)
  - Redmond, WA
- Schafer Corporation
  - Huntsville, AL

Goals:

1. To Conceive, Design, and Fabricate a LFL Seeker Projectile
2. To Demonstrate in Two Years:
   a. Working Breadboard of the Projectile
   b. Fabricate and Fire Inert Projectiles
   c. Perform Course Corrections in Flight

U.S. Army Non-Lethal Capability
On point, Defending Freedom

2002 International Infantry & Small Arms Symposium,
Exhibition & Firing Demonstration

21st Century Military Operations and Technology

Seham Salazar
Project Officer - NLCS
U.S. Army OPM-MCD
Com (973) 724-6296

14 May 2002
Atlantic City , NJ

OUTLINE

- DoD NLW Policy
- Organizations and Roles
- Non Lethal Capabilities Set
- Fielding Support
- Summary

Why Non-Lethal?

DoD Directive 3000.3, 9 Jul 96

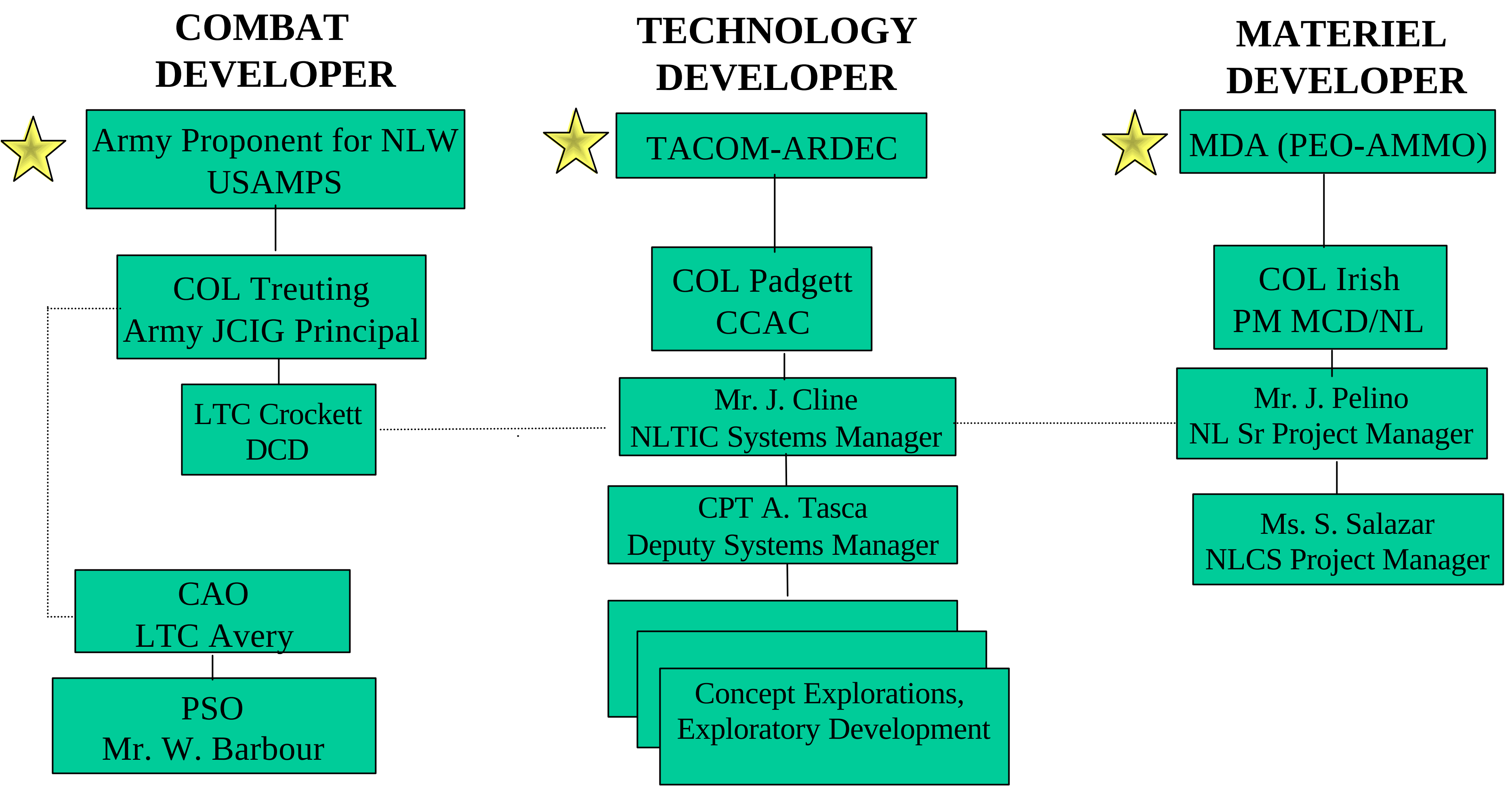
Policy for Non-lethal Weapons (NLW)

. . . **Designates** . . . Commandant of the Marine Corps Executive Agent for the DoD NLW Program . . .

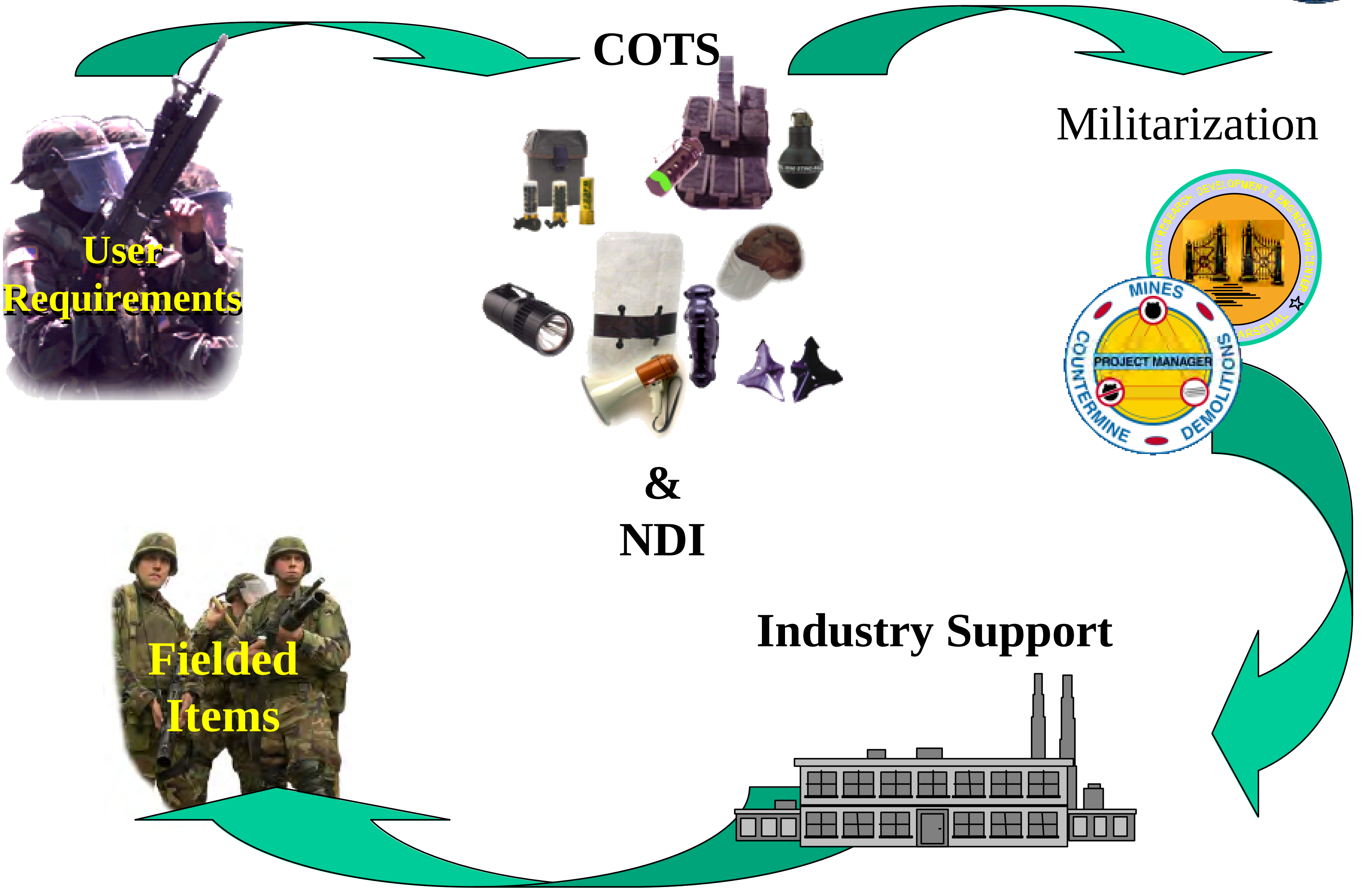
. . . **Defines NLW** . . . "weapons that are explicitly designed and primarily employed so as to incapacitate personnel or materiel, while minimizing fatalities, permanent injury to personnel, and undesired damage to property and the environment."

. . . **Directs** . . . Services to participate in NLW program

Army NL Organizational Structure



NLCS/Industry Partnership



Non-Lethal Capabilities Set (NLCS)

- *Versatile Package of COTS, GSA & NDI Items as Well as Materiel Released Capabilities*
- *CINC Requested & DA Directed Program to Procure & Field 30 Sets in FY00 – 05*
- *Operational Requirements Document in Staffing*









DESCRIPTION

Currently 45 Items

1. - Munitions
2. - Individual Protective Equip.
3. - Individual Enhancement Equip.
4. - Mission Enhancement Comp.
5. - Training Components

Individual Protective Equipment

In Modern Peacekeeping scenarios the soldier is required to maintain a highly visible and vulnerable position. The Non Lethal Capabilities Set is designed to provide the soldier with the means to avoid injury during civil confrontations.

Non-Ballistic Riot Face Shield
Non-Ballistic Riot Body Shield
Non-Ballistic Riot Shin Guards

Ballistic Face Shield
Ballistic Body Shield
Ballistic Shin Guards

Individual Enhancement Devices

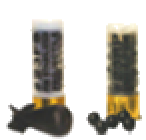
Individual Enhancement Devices are items of general issue that provide the soldier with the means to carry his non-lethal munitions and insure his personal protection

- Hickory Riot Baton
- Individual RCA Disperser
- Disposable Restraints
- Individual Voice Amplification System-M
- Individual High Intensity Light
- 12 GA Utility Pouch
- 12 GA Buttcuff
- Diversionary Grenade Pouch
- 40mm Pouch

Munitions

The Non-Lethal Capabilities Set contains a wide range of specialized munitions to provide the field commander with variety of options for any situation

- Refill, CR Riot Control Agent
- 5.65 Point Round
- 5.65 Area Round-XM95
- 12 GA Point Round-M1012
- 12 GA Area Round-M1013
- 12 GA Diversionary Round
- 12 GA Launching Cup Cartridge
- 40mm Sponge Point Round-M1006
- 40mm Area Round
- Diversionary Hand Grenade-M84
- Rubber Ball Hand Grenade
- 66mm Area Round-XM99
- 66mm Diversionary Round-XM9866mm RCA Round-L96E1
- Modular Crowd Control Munition-M5



Training Devices

The proper use and deployment of the Non-Lethal Capability Set runs counter to the normal doctrines and training that govern war. Familiarization with these new devices and techniques are essential.

12 GA Dummy Round
L97E1 – 66mm Training Round
Inert Individual RCA disperser
Riot Training Suit
Riot Training Bag

Mission Enhancement Devices

Mission Enhancement Devices provide additional capabilities for Force Protection, Area Denial and Command and Control

Portable Bullhorn

Ground Mounted Bullhorn

High Intensity Light Kit

Batteries and Replacement Lamps

Mid-sized RCA Disperser-M37

12 GA Launching CupLVOSS-M315

Portable Vehicle Arresting Barrier-M1

Caltrops

An Urgent Need – A Growing Demand!

- *Since 1995 the Army Has Increasingly Recognized the Need for Scalable Effects Capabilities for SASO & PSO Missions.*
- *Since March of 2000, OPM-MCD Has Been Working to Meet That Need W/ the Army's First Non-lethal Capabilities Set (NLCS).*

April 2000
TFF, KFOR, Kosovo
(MG Caldwell)

June 2001
USA FORSCOM
(MG Caldwell)

June 2001
TFE, SFOR, Bosnia
(MG Caldwell)

Operation Enduring Freedom!

April 2002
SOUTHCOM,Guantanamo Bay
(MG Thompson)

January 2002
ARCENT, Kuwait
(MG Thompson)

Summary

The face of war is changing and OPM MCD is partnering with Industry to meet the challenges of tomorrow's battlefield leading the way with advanced systems.

- Non Lethal Program is Guided by DoD Directive
- Technology Evolution will continue to support Transformation

2002 International Infantry &
Joint Services Small Arms Symposium

OICW Non-Lethal Munition

14 May 2002

Camilo A. Sanchez
US Army TACOM-ARDEC
Close Combat Armaments Center
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Pre-Milestone A Program

Program: Objective Individual Combat Weapon Non Lethal (OICW NL) Munition

Concept:

• Exploit the ability of the OICW to airburst munitions at a precise location in space to emplace or employ NL concepts.

OICW NL Risks and Challenges

- Potential lethal injurious effects from projectile airburst and parasitic mass
- 20 mm Volume limitations on payload effectiveness
- Fuzing development (MEMS S&A)
- Burst point precision

Key Participants

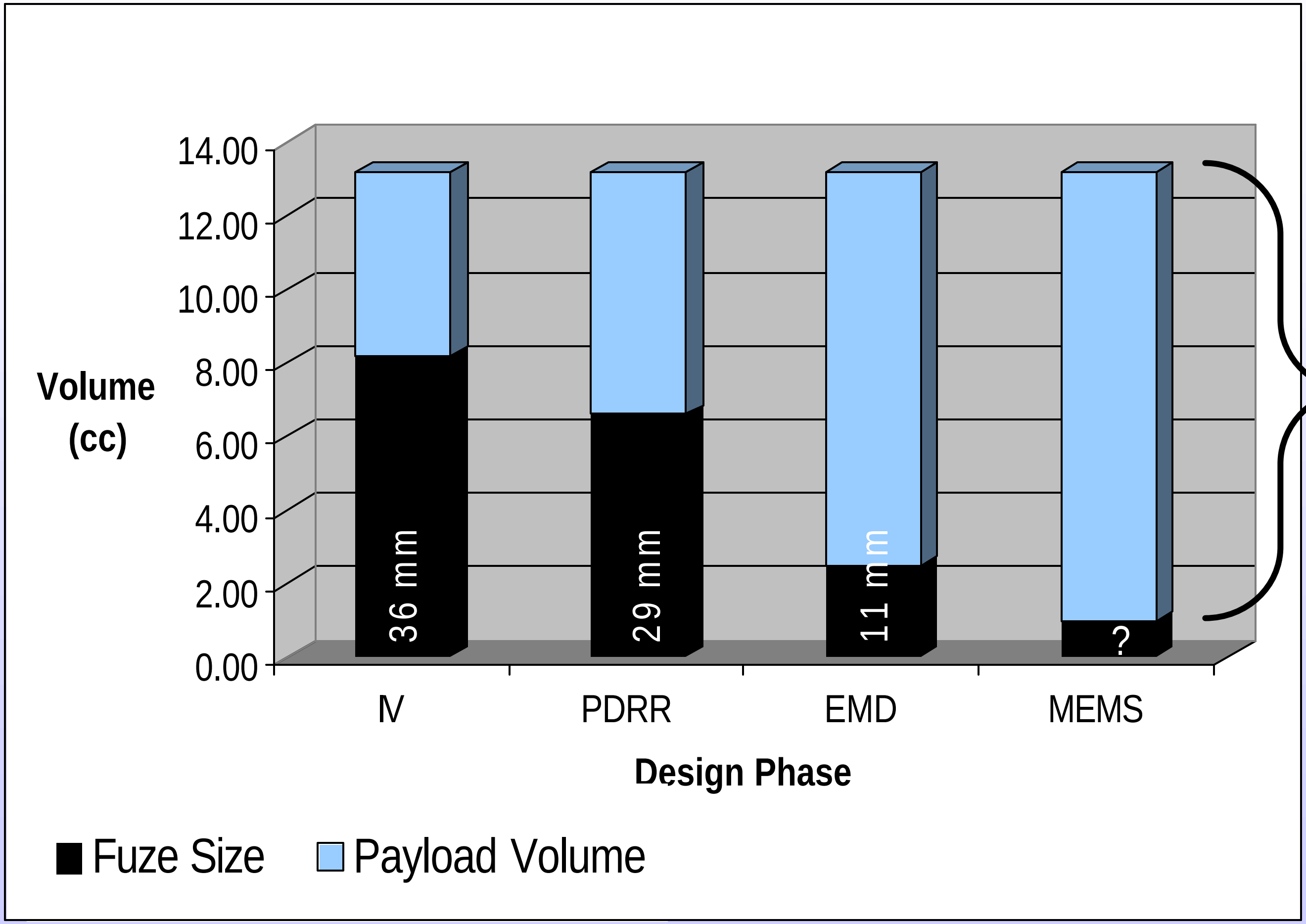
Lab/Office	POC	Phone
• TACOM-ARDEC Projectile Design	F. Dindl	(973) 724-6761
• SBCCOM/ECBC Modeling & Simulation, Payload Experiments	L. Bickford	(410) 436-2231
• Oak Ridge NL Frangible Materials Development	Dr. Lowden	(865) 576-2769
• PM OICW OICW Interface	T. Hartmann	(973) 724-8515
• Alliant Techsystems Maple Grove, MN Parts and Services		
• JNLWD Quantico, VA Sponsor, Requirements Generation	M. Grussendorf	(703) 784-2646

Concepts carried forward

- Integrated Proximity Sensor w/ Reverse Thrust Concept
(not pursued because of multiple technologies required for development)

- Controlled Residual Kinetic Energy Concept
(selected concept)

OICW Fuze vs. Payload Volume



- NL Agent over 2X current amount.
- Incapacitation area maximized
- More effective over harsher atmospheric conditions

Program Documentation

Document Title	Approved	
• Pre-Phase A Exit Criteria (MS A Entrance Criteria)	26 Apr 00	JNLWD RIG
• OICW NL Preliminary Legal Review	06 Jul 01	
• OICW Approved ORD	24 Feb 00, Draft Rev 24 Mar 02	
• SCG for JNLW Program	Apr 98, Draft Rev May 01	
• SCG for OICW	Aug 00, Draft Rev 22 Mar 02	

OICW Non-Lethal Munition Milestone A Entrance Criteria

•Operational Input

	Criteria	Threshold	Goal
	Dispense Payload:	250m	5m-1000m
	Technology Readiness Level (TRL)	4	5

TRL 4 – Component and or breadboard validation in a laboratory environment

TRL 5 – Component and or breadboard validation in a relevant environment

OICW NL Technical Demonstration

- Ballistic test conducted 12 Feb 02
- Attended by SOCOM, Army, AF, JNLWD representatives
- Fired several cartridges to function @ 250 m
- Witness panel to initiate projectile
- A surrogate fuzing system was utilized
- Target (rigid foam) 5 m beyond witness panel

Results

- Demonstrated ranged initiation and disperse simulant (smoke pellets)
- All parasitic mass non-lethal
- Projectile velocity reduced to non-lethal levels after airburst
  - Projectile recovered laying between witness panel and target
  - No perforation of target
  - No projectile rupture

OICW NL Payload Tests

Payload Test set up (Jan 02)

- Pyrotechnic CS – 3/16 in, 1/4 in pellets – 5-6 gms, starter mix, electric match, kraft paper
- CS initiated using various burst scenarios (0, 250, 500, 750, 1000 fps)
- 3 filter readings, 35 liter/minute, mixing fan

Results

- Max average airborne CS - .16%
- Pellets not optimized
- Airspeed may have prevented CS dissemination
- Below calibration limits of analytical procedure used

OICW NL Payload Tests

Payload Test set up (19 Apr 02)

- Pyro CS ground 3/16-in pellets (3.2g)
- Bulk CS1 (1.6g)
- Custom spin fixture (10,400 rpm) to simulate projectile in flight spin rate
- 3 filter readings, 35 liter/min, mixing fan
- More realistic expulsion conditions

Results

- Pyro CS: three round average, 0.09g airborne (measured) yielding 7% airborne CS
- Bulk CS1: three round average, 0.51g airborne (measured) yielding 32% airborne CS

CS Payload Summary

- Pressed/Cast CS - HE ruled out as dissemination technique
  – Required standoff was believed to be high
- Pyro/CS - Poor performer
  – 60 % pyro required
  – Pellets not optimized
- Bulk CS1 - Best approach to date
  – Need to increase CS packing density to 8.4 gm
  – Need to maximize airborne yield – 32% to 70%

OICW NL Human Effects

• The preliminary focus is on CS effect and overcoming the KE of projectile near target.

• Working with Human Effects Center of Excellence (HECOE), Brooks AFB, TX to evaluate effects on the target – both effectiveness and risk to the target's health and safety

• Provided 20 vs. 40mm Payload Analysis to HECOE - May 01

• Submitted Target Human Effects Evaluation Plan (THEEP) - 10 Jan 02

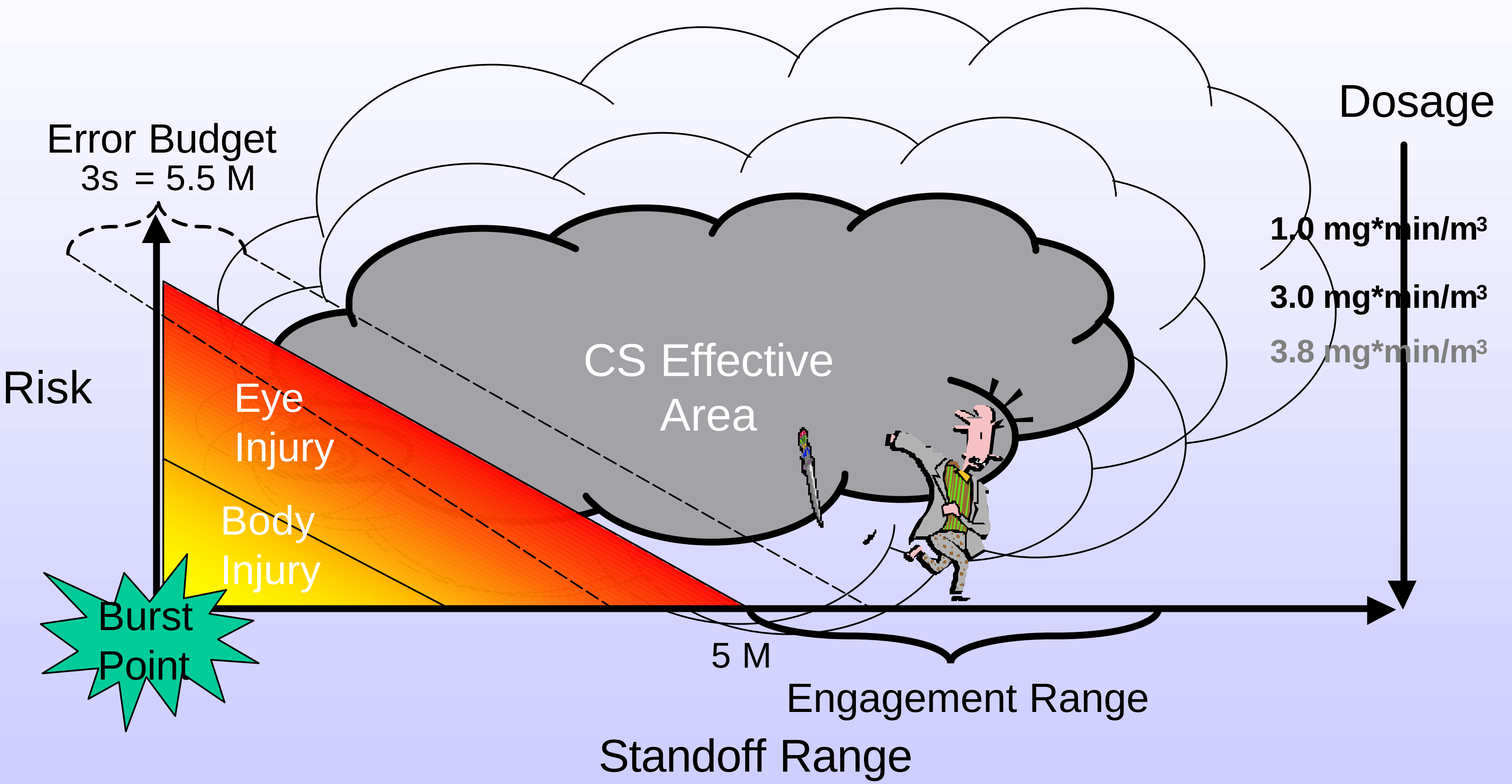
• Initial Human Effect Review Board (HERB) meeting scheduled - 11 Jul 02

OICW NL Human Effects

Target Human Effects Evaluation Plan (THEEP)

- RCA (CS irritant) effectiveness against the intended: Target Response
  - CS Dosage - CS incapacitation metric needs further definition
  - CS route of entry - ocular (eyes), cutaneous (skin), and inhalation (breathing).
- Collateral health hazards to humans: Risk of unintended Effects
  - Blunt trauma due to incomplete/improper deceleration
  - Eye injury – CS, Tungsten Powder
  - Skin perforation – CS, Tungsten Powder
  - Inhalation/lungs – Toxicology
  - Other: Heat, Noise

Conceptual Delivery Effects



Legal

Legal Issues: None

- Army JAG preliminary legal review received 06 Jul 01

•Concludes that the NL Airburst OICW munition concept appears consistent with law obligations of the US, including law of war.

•Memorandum was coordinated with the Navy JAG and the Staff Judge Advocate to the Commandant of the Marine Corps, who concur with its analysis and conclusions.

"An OICW non-lethal munition poses no new questions with respect to unnecessary suffering."

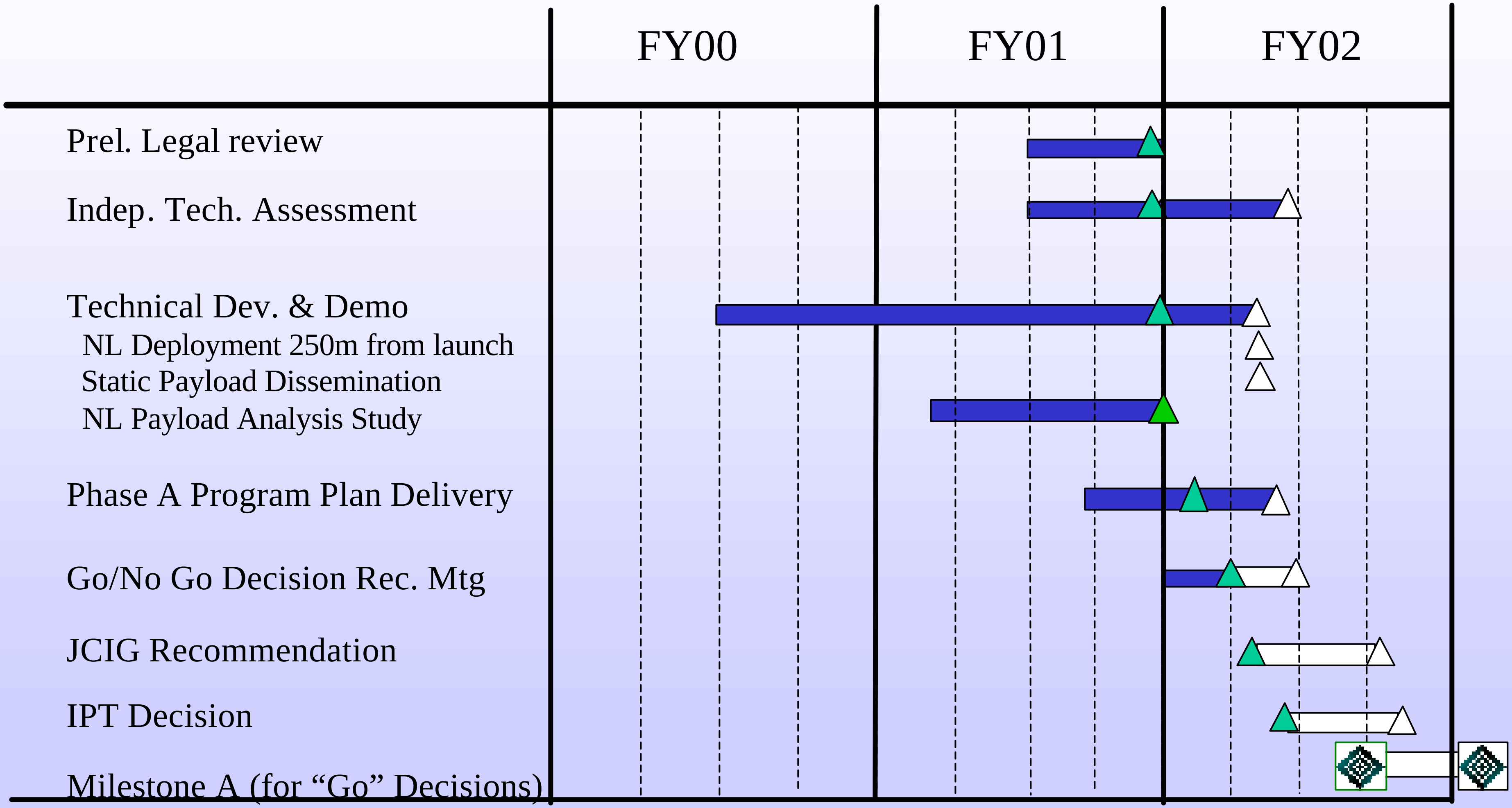
Program Accomplishments

• Favorable Preliminary Legal Review received – Jul 01
• Conducted Technical Demonstration – 12 Feb 02
• Penn St U Independent Technical Review Panel assessed technical feasibility and military worth of the OICW NL munition – 25 Apr 02
• Revisited Chamber test for CS payload effectiveness – 19 Apr 02

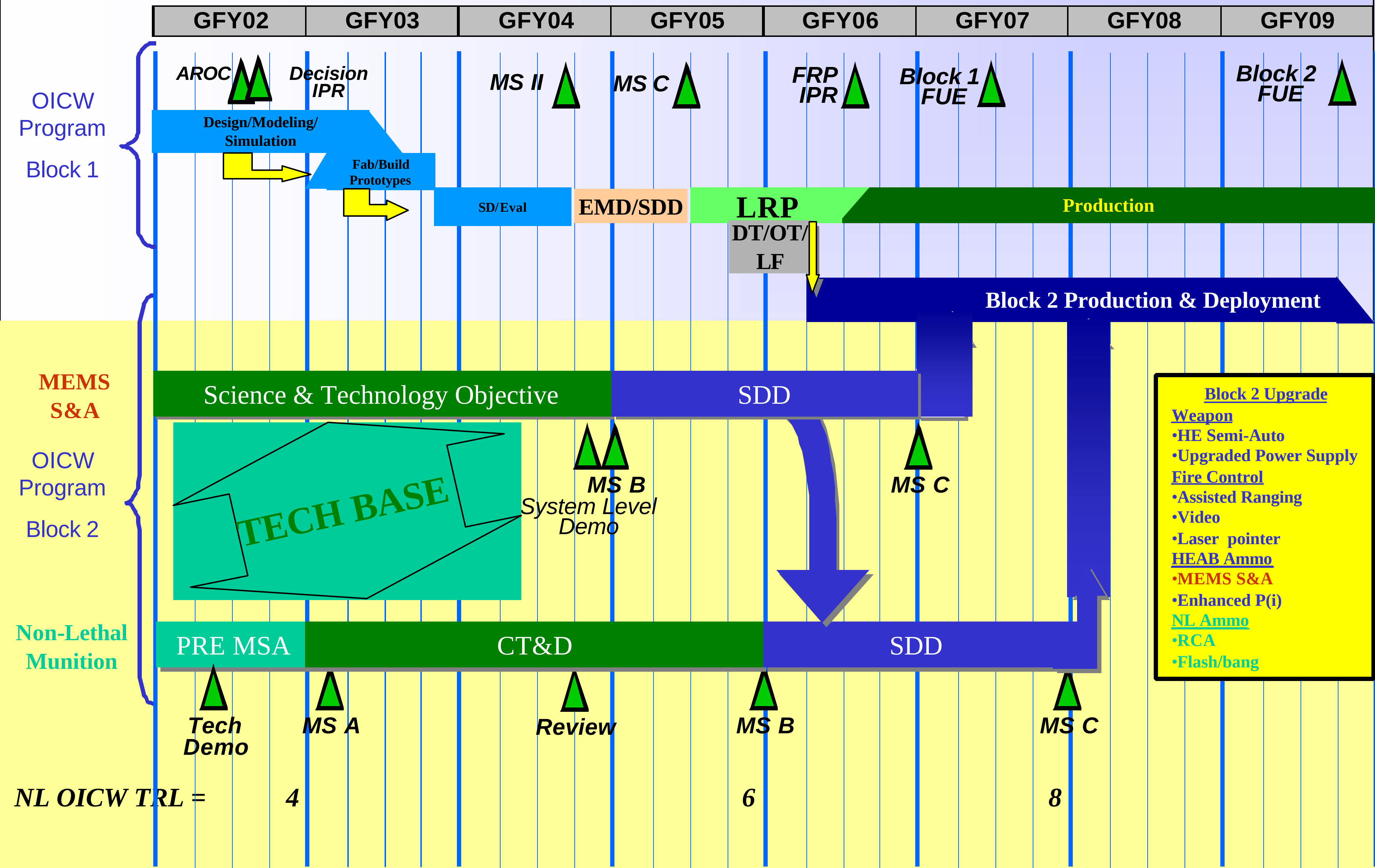
Future Plans

• Go/No go Decision meeting – 29 May 02
• Milestone A Decision – 1Q FY03

Pre-MSA Schedule
for the OICW NL Munition



OICW System Schedule
Non-Lethal & MEMS S&A Development



Field Experiment Results of the CARMEL II Laser Crosswind Sensor

Raymond Von Wahlde
(US Army Research Laboratory)
Dr. Joseph Shapira
Mordechai Livneh
(SOREQ Nuclear Research Center, Israel)

CARMEL II

Crosswind And Range MEasurement Lidar

- 20 cm Wide, 13 cm Tall, 30 Cm Long

CARMEL II

- A unique fire control device
- **Remotely** measures, in **real time**, both
  - **RANGE** to target
  - a path-averaged **CROSSWIND** profile between the shooter and target.
- Can be programmed for different types of munitions and sight parameters
- Correction of crosshairs can be automatic and/or manual
- Patent No.: US 6,247,259 B1(Method and Apparatus for Fire Control) SOREQ NRC

US006247259B1

(12) **United States Patent**
Tsadka et al.

(10) **Patent No.:** **US 6,247,259 B1**
(45) **Date of Patent:** **Jun. 19, 2001**

(54) **METHOD AND APPARATUS FOR FIRE CONTROL**

(75) Inventors: **Sagie Tsadka**, Yavne; **Ehud Assoulay** Rosh-Ha'ayin; **Gideon Bar-Tal**, Ranana, all of (IL)

(73) Assignee: **The State of Israel, Atomic Energy Commission, Soreq Nuclear Research Center** (IL)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/168,258**

(22) Filed: **Oct. 8, 1998**

(30) **Foreign Application Priority Data**

Oct. 9, 1997 (IL) 121934

(51) **Int. Cl.**[7] **F41G 1/36**
(52) **U.S. Cl.** **42/103; 89/41.06; 89/41.17**
(58) **Field of Search** 42/103; 89/41.17, 89/41.06

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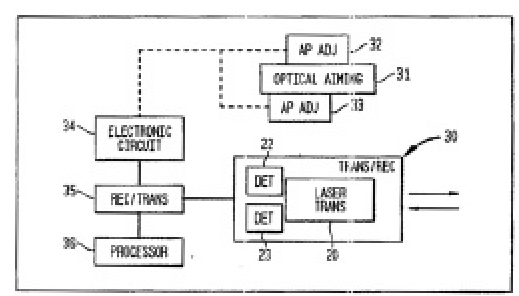
* cited by examiner

Primary Examiner—Stephen M. Johnson
(74) *Attorney, Agent, or Firm*—Lerner, David, Littenberg, Krumholz & Mentlik, LLP

(57) **ABSTRACT**

A method for the fire control of flat trajectory weapons, which comprises the steps of measuring the target range and cross wind velocity along the intended projectile trajectory prior to firing the weapon and, using the know ballistic equations of the projectile, determining the expected vertical and horizontal deflection of the projectile and adjusting the weapon sight to compensate for said deflections.

11 Claims, 8 Drawing Sheets



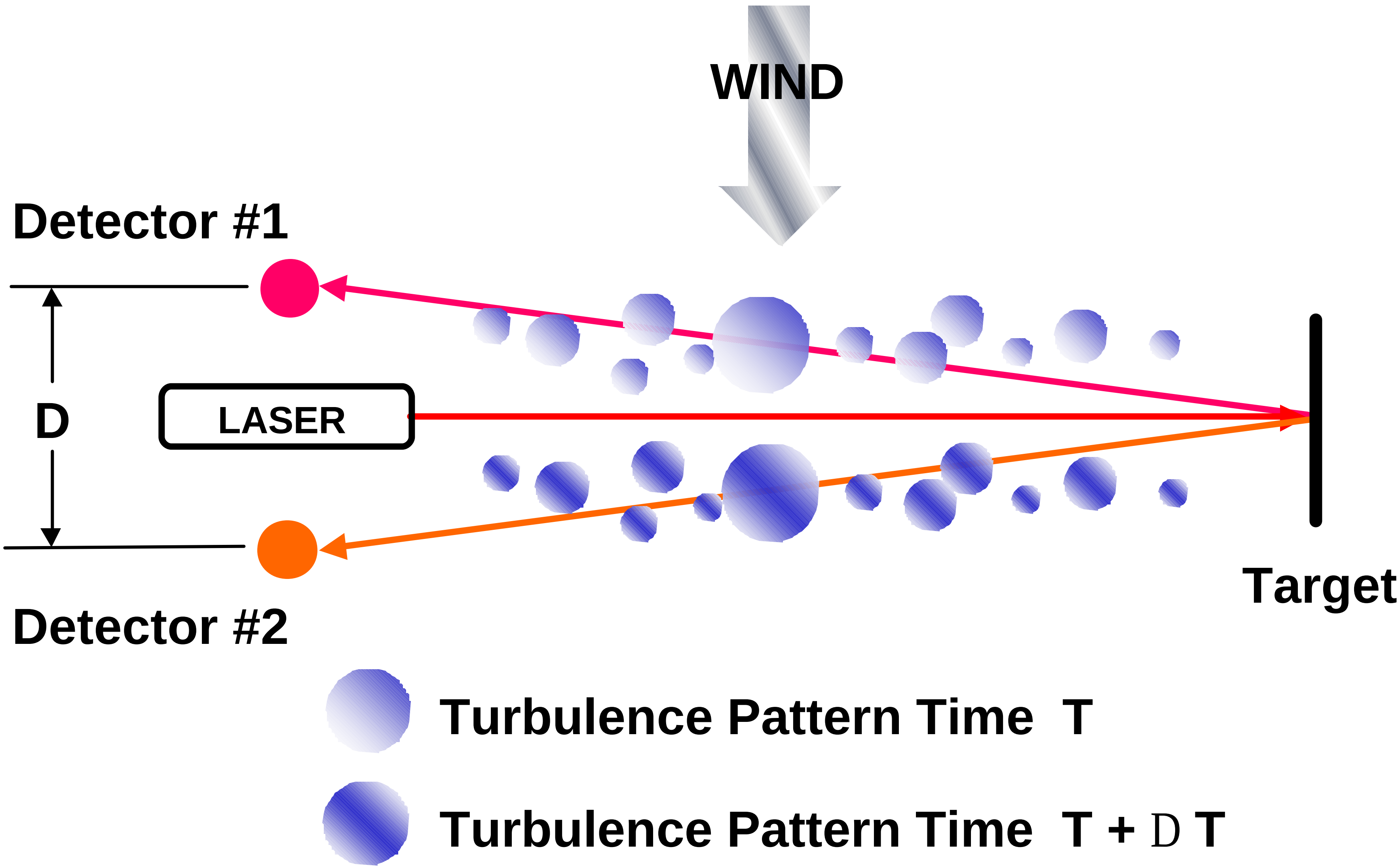
CARMEL II Scintillation-based Shooters' "Mirage"

- Scintillation akin to "mirage"
- Mirage :
  - windage method preferred by many shooters
  - defocused scope
  - refraction of light through layers of air of different temperatures and densities
- Shooter views the distortion of light from the target as the distortion-causing turbulence cells drift with the wind.
- Shimmer appears to move with the same velocity as the effective wind.
- Technique works well.
- Fails for winds above 12 mph, at which the movement of the mirage becomes too swift for a shooter to detect.
- Fails at times when mirage is not visible to the shooter, namely, at dawn, dusk, and night.
- Scintillation often still detectable when "mirage" is not.

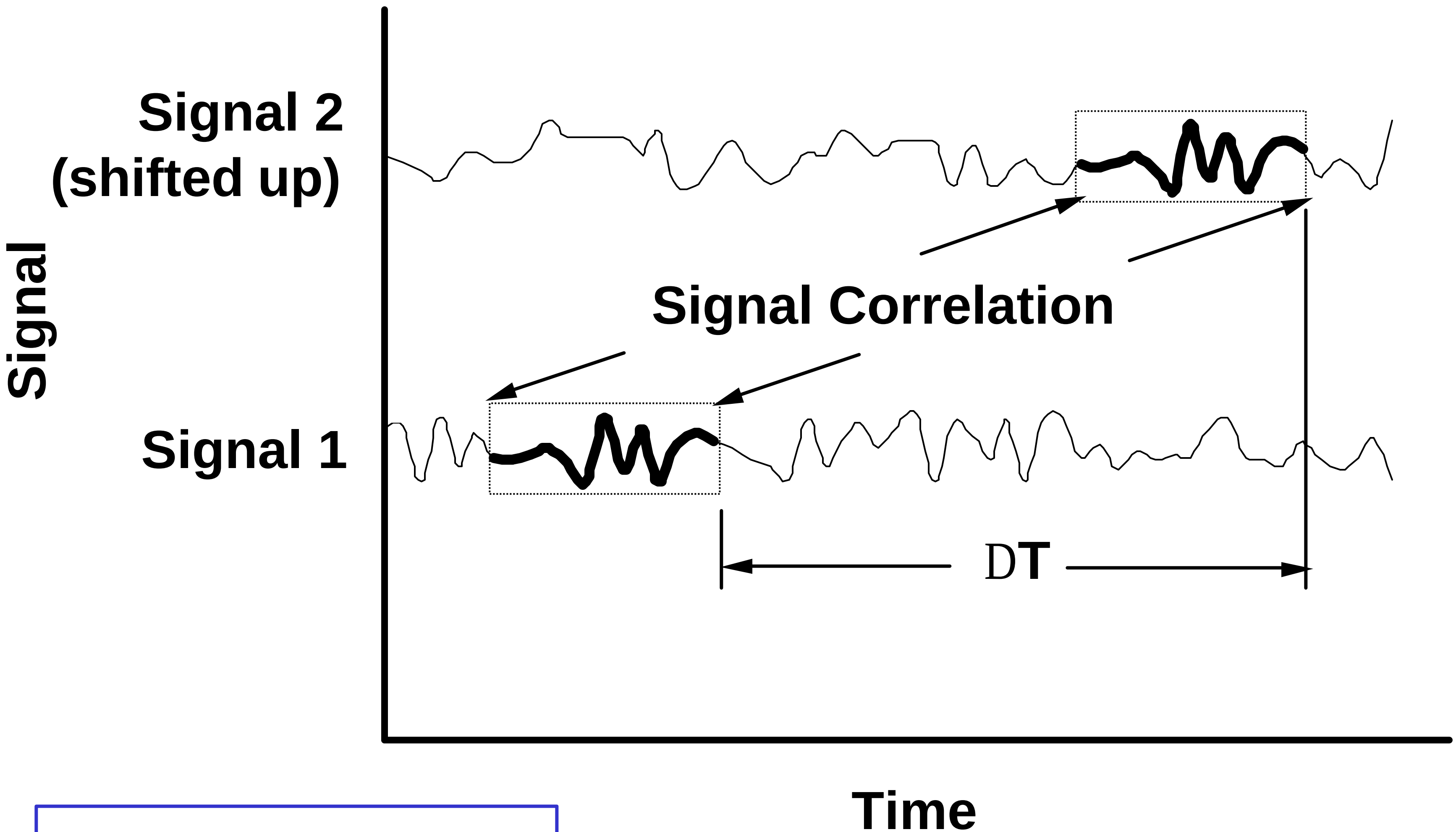
CARMEL II
Principle of Operation

- Target is illuminated by a compact, covert-wavelength laser aligned with the gun.
- Atmospheric Turbulence induces temporal power fluctuations on the laser pulse reflected from the target.
- The system measures these fluctuations using horizontally spaced detectors.
- The time lag of the two detectors’ intensity correlation function corresponds to the crosswind.

CARMEL
Principle of Operation (cont.)



CARMEL
Principle of Operation (cont.)

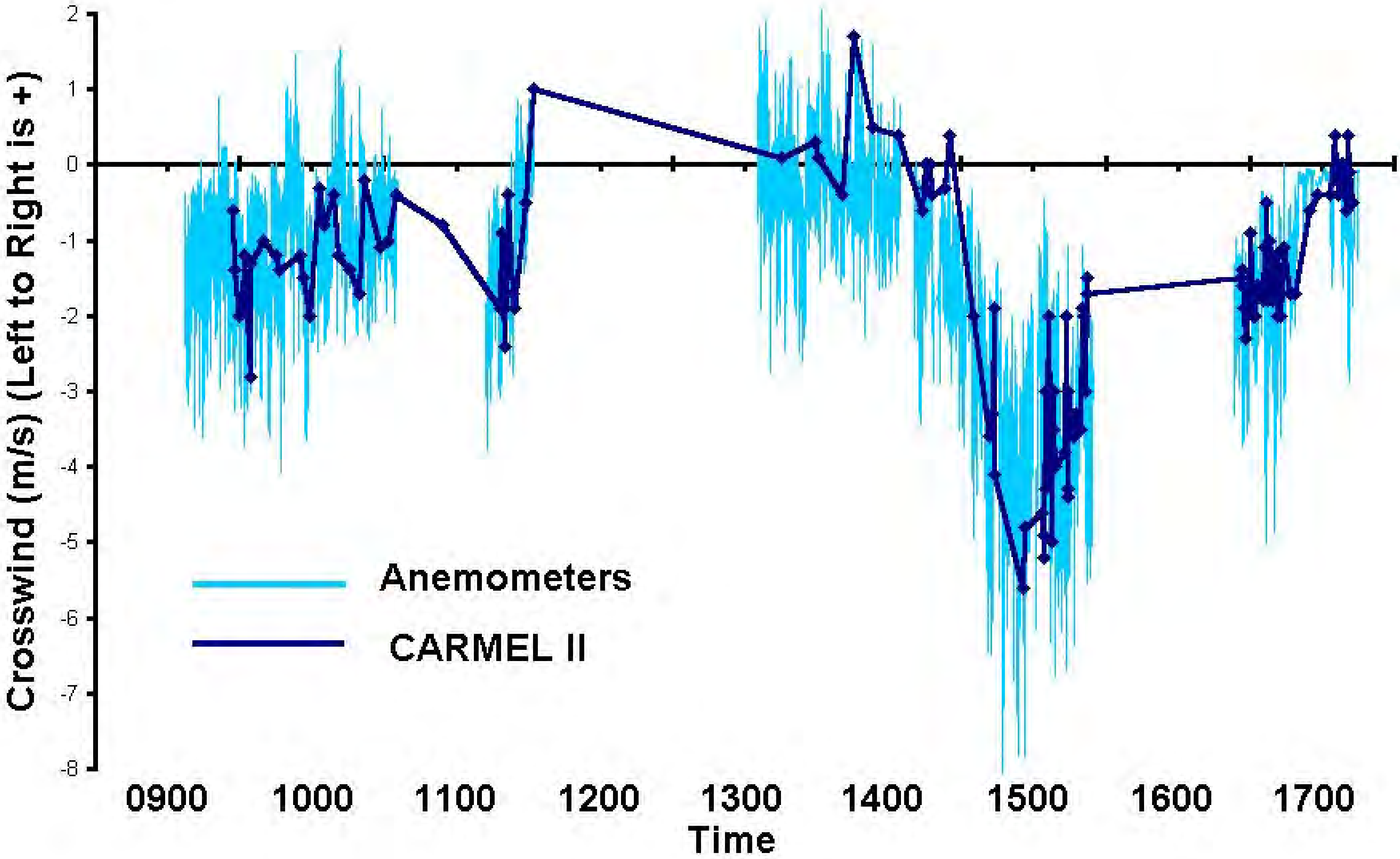


Crosswind = D / DT

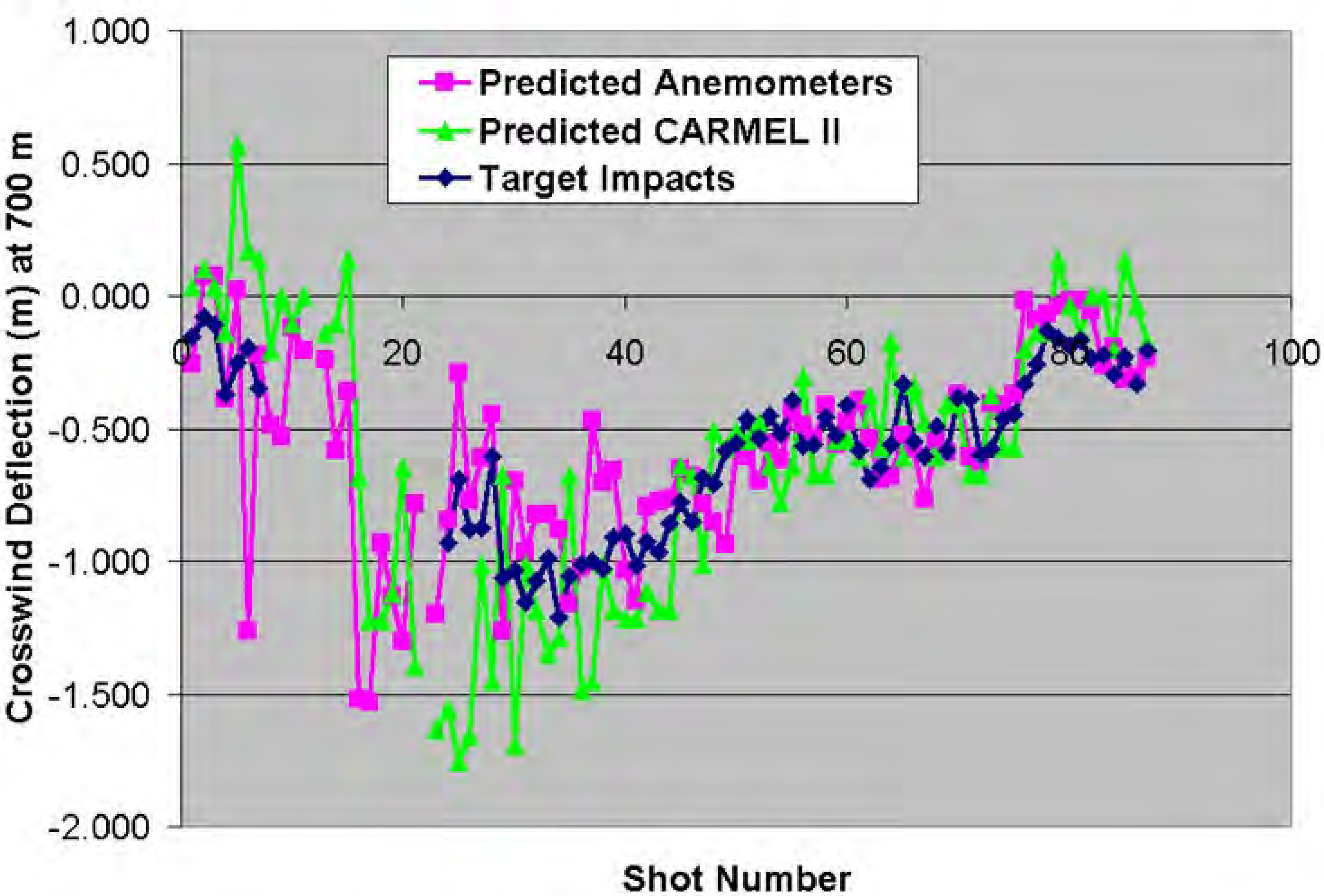
Dec. 2001, APG Field Experiment

- Week long test over which we hoped
  - for varied wind conditions
  - to operate through at least one dusk
- M24 rifle locked in Franklin rest
- 7.62mm NATO BALL ammo
- Target 700m
- Anemometers at 6, 55, 125, 310m
- Turbulence Measurement
- Electronic Scoring system in front of target
- Shot at known aimpoints
- Recorded Impacts
- Compared actual with predicted crosswind deflections

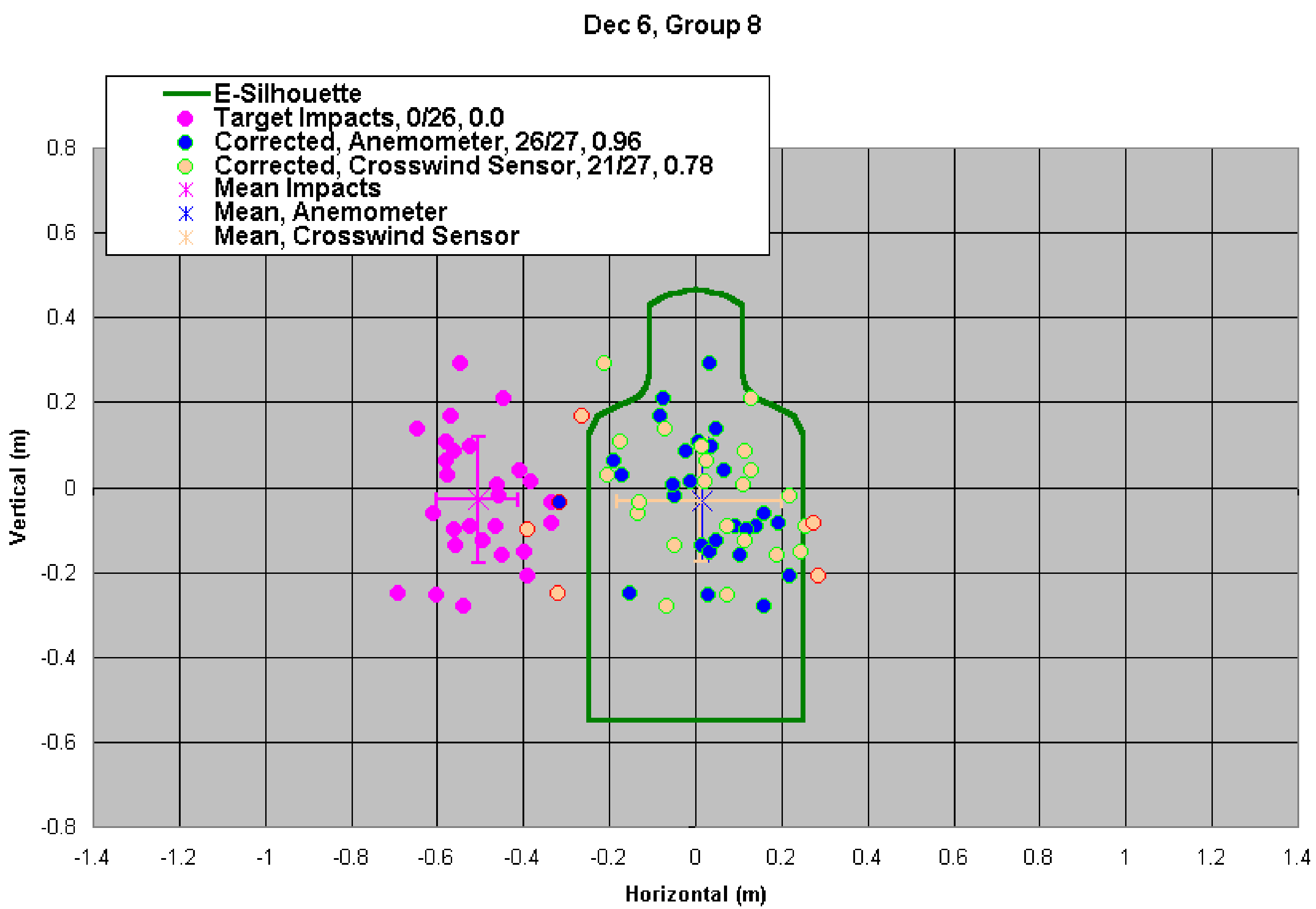
Crosswind vs. time



Crosswind vs Shot

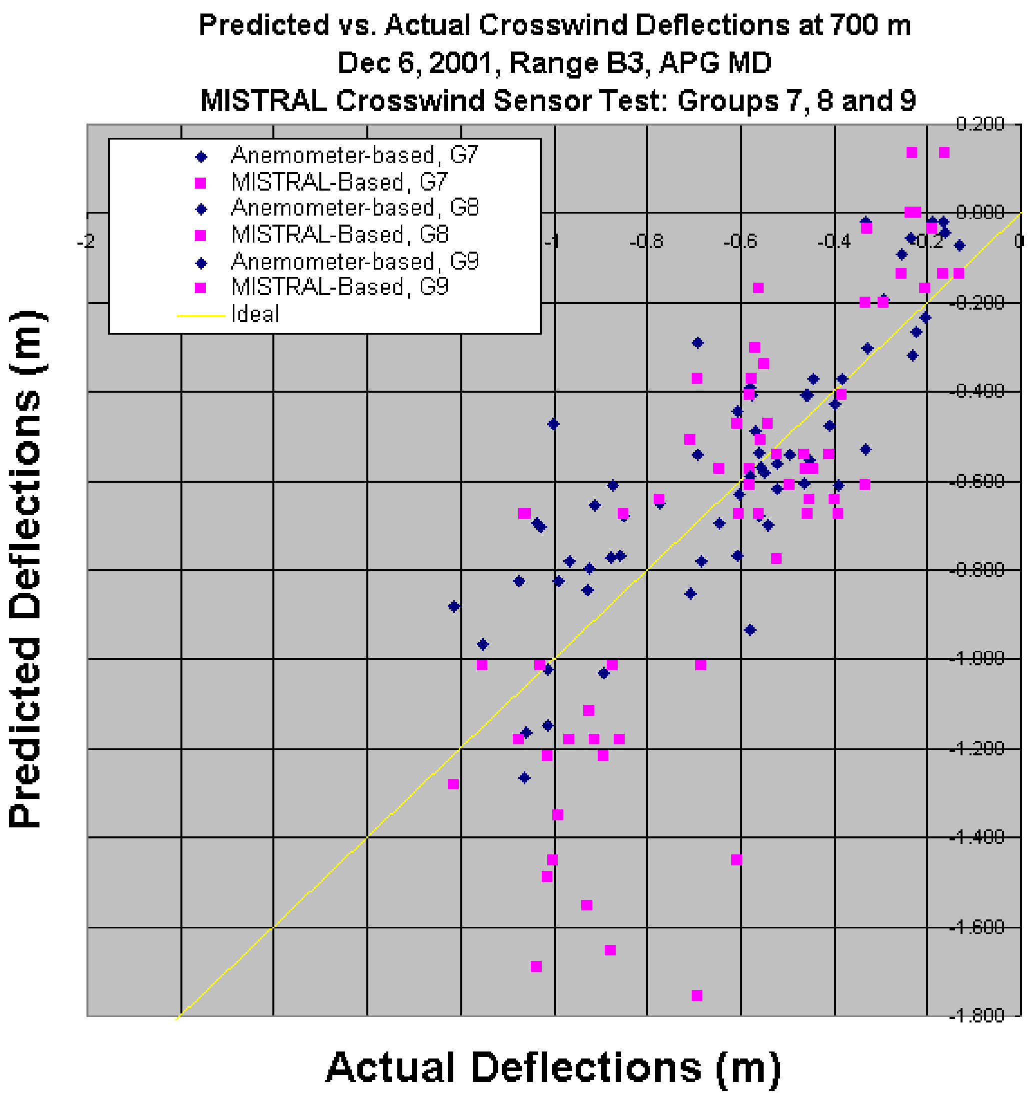


Shot Groups



Dec 6, Group 8
E-Silhouette
Target Impacts, 0/26, 0.0
Corrected, Anemometer, 26/27, 0.96
Corrected, Crosswind Sensor, 21/27, 0.78
Mean Impacts
Mean, Anemometer
Mean, Crosswind Sensor
Vertical (m)
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1.4
-1.2
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1
1.2
1.4
Horizontal (m)

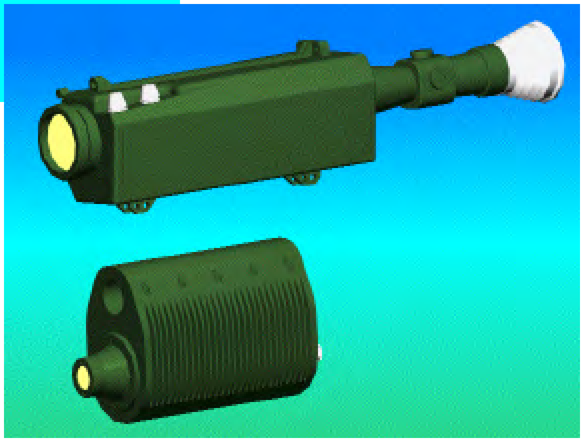
Predicted vs. Actual



CARMEL III
Custom Configurations

- Stand Alone:
  - System Off-weapon
  - Range and Crosswind Measurement Presented to Operator on a Digital Display
- Semi-integrated:
  - Off-weapon
  - Ballistic Corrections Computed from Measured Data for Selected Ammunition Type
  - Weapon's sight aim-point is controlled by the system
- Fully Integrated:
  - System integrated into weapon sight
  - Full Fire Control Capabilities
  - Automatic aim-point configuration

CARMEL III
(Rifle-Mounted Version)



TACOM

Lethality, Survivability, Mobility and Sustainment for America's Army

Objective Force Warrior Lethality
14 May 2002

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Committed to Excellence

Approved For Public Release

Soldiers on Point for the Nation Video

- Stimulate the technology community
- Visionary concept for a revolutionary soldier
- Army Chief showed it at the Winter AUSA
- 2015 time frame
- Technologies include: quantum computing, nanotechnologies, exoskeleton, robotic UAV (eagle), robotic Mule, speech recognition, vision computer pointers, integrated suit and helmet, netted fires, etc

Objective Force Warrior Program

- Warrior Piece of the Objective Force
- An integrated system of systems approach enabling a team-of-teams operation
- A Combined Arms Force at the Fire Team Level
- Fielding Timeframe: FUE 2008-2012

A Revolutionary Capability For The Objective Force

Objective Force Warrior Program

- Two Lead Technology Integration contracts awarded FY 02 by Natick Soldier Center

- Technology Demonstration FY06

- Technology Readiness Level 6

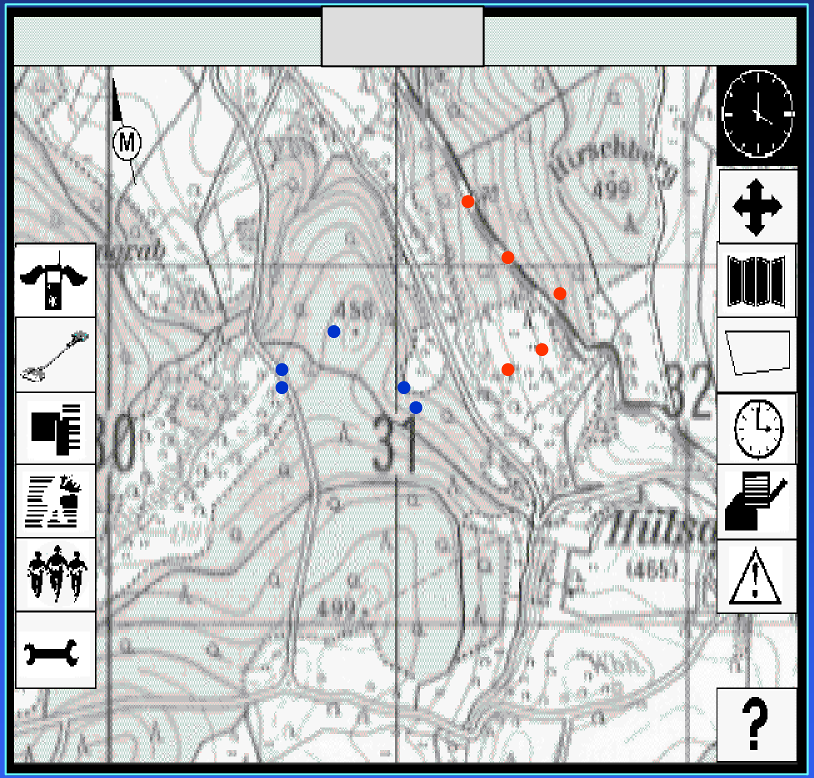
- FUE FY08-12

Objective Force Warrior Lethality Vision

- Broader View of Battlefield
  - Improved situational awareness
  - Target & combat identification
- Improved Squad Performance
  - Networked fires
  - Decision aids
  - Control fires of remote weapons
- Increased Lethality and Capability
  - OICW
- Lightweight Weapon Family
  - 30-35% lighter than legacy systems
  - Compliment highly lethal OICW in squad

Future Lethality Improvements

Information Technology



More Target Relevant Information

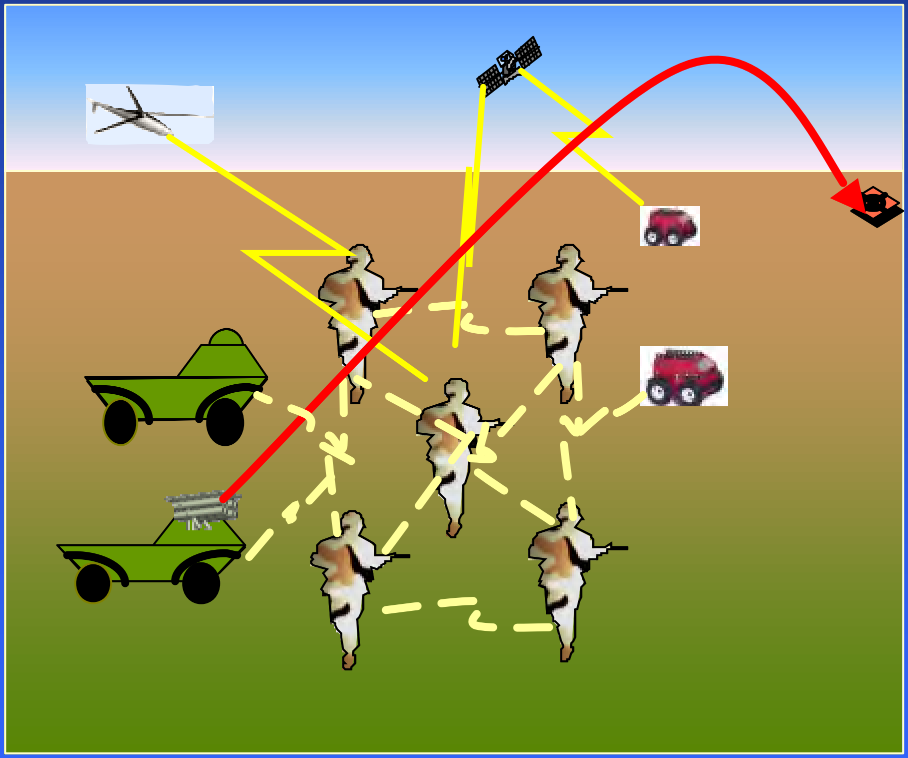
- Squad level networked sensors
  - Fuzed image
  - Auto trackers
  - Multifunction steerable lasers
  - Acoustic recognition
  - Combat ID
- Detect Targets
  - Locate
  - Identify friendly or other
  - Prioritize based on range motion type or other attributes

Future Lethality Improvements

Netted Fires

Squad Networked Fire Control

- Provides target information and aiming solution to any soldier
- Allows best shooter / best weapon to engage target
- Allows for direct control of remote or robot weapons
- Provides decision aids to squad and team leader
- Monitor ammunition usage with automated call for resupply



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Future Lethality Improvements
Situational Awareness

• Soldier must keep eyes on battlefield to maintain awareness
• Reading maps and aiming a weapon cause a temporary loss of awareness

• Future warrior may be able to engage targets without shouldering a weapon
  • aiming reticle projected in normal field of view
  • like fighter pilot displays

• Advantages
  • quickness and speed of fire
  • maintain full awareness of battlefield
  • less weight on weapon

Future Lethality Improvements

More Lethal

- **Objective Individual Combat Weapon**
  - laser range finders
  - ballistic computers
  - electronic fuzes
  - airbursting munitions

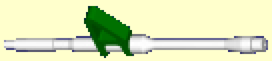
- **Provides**
  - ability to airburst munitions near the target
  - significant increase in performance & higher probabilities of incapacitation
  - ability to defeat non line of site targets
  - increased stand off
  - increased survivability
- **Limited Basis of Issue**
- **FUE FY07**

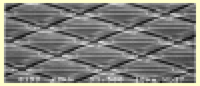
Future Lethality Improvements

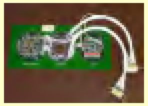
Lighter Weight

Potential

- 30-35% weight reduction possible
- Complement OICWs in Squad
- Loaded M4 from 7.4 lbs to 5 lbs
- Loaded M249 from 23.3 lbs to 14 lbs
- 6-30 rd magazines from 6 lbs to 4lbs


Ceramic Barrel

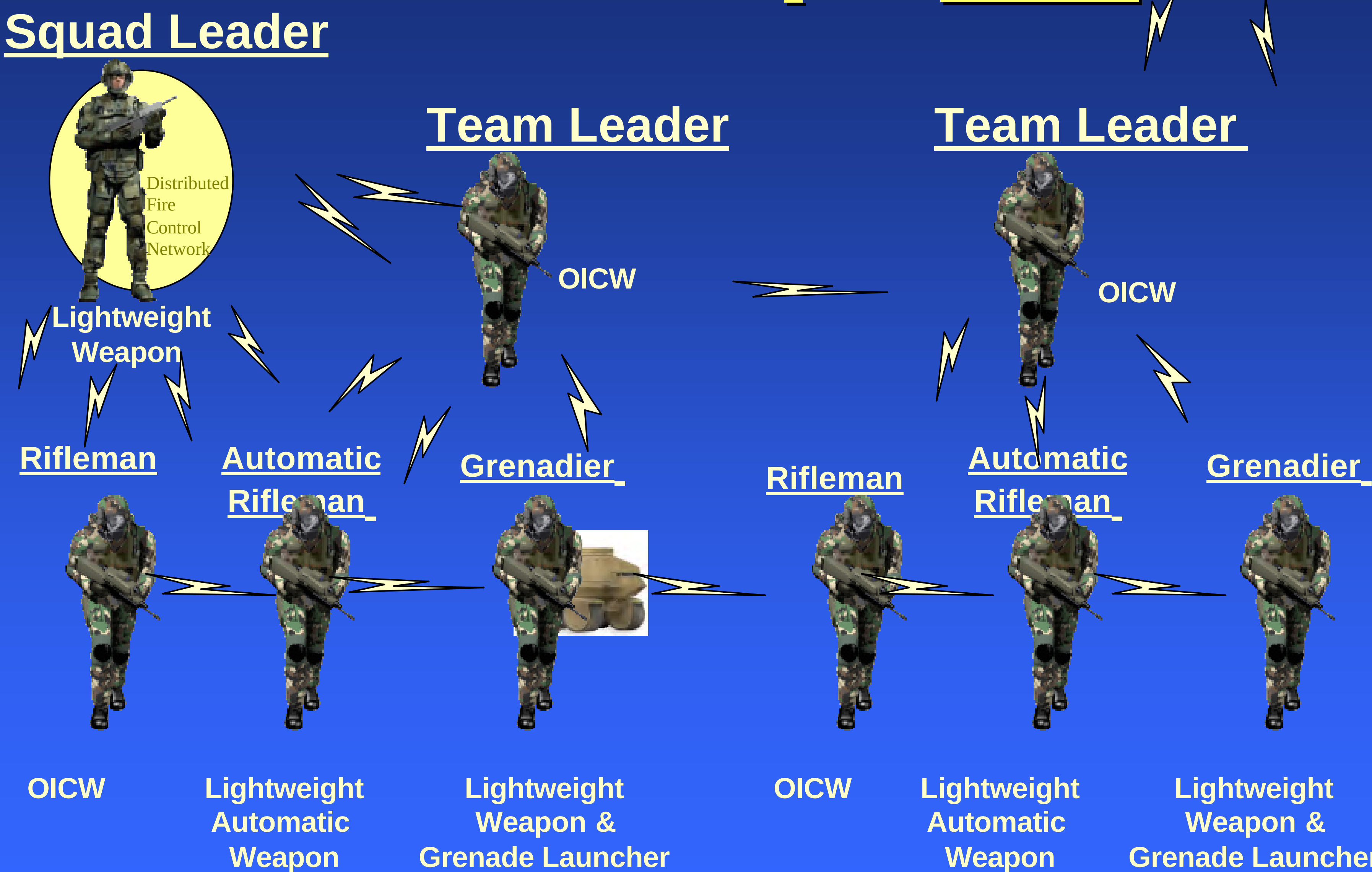
Composite Structures


Embedded Sensors


Caseless or Plastic Cased Ammunition


Simple Reliable Mechanisms


Objective Force
Warrior Rifle Squad Vision



Summary

OFW Lethality

• JSSAP will work with Natick and the Lead Technology Integration contractors to define and demonstrate the Lethality of the OFW

• JSSAP will initiate an effort to demonstrate a new family of lightweight weapons

  • Carbine
  • Automatic Rifle
  • Medium Machine Gun
  • Indirect Fire Attachment

• Compliment OICW and OCSW in Rifle Squad and Weapon Squad

NORTH ATLANTIC COUNCIL
NATO ARMY ARMANENTS GROUP

Topical Group 1 on Soldier System Interoperability

Mr. Vernon E. Shisler
Chairman

LtCol Koos Meijer
Deputy Chairman

Topical Group 1 on Soldier System Interoperability

- **Chairman:**
  - Vernon E. Shisler
  - Army Armaments Research Development & Engineering Center
- **Head of Delegation:**
  - LTC Cindy Bedell
  - Program Manager Soldier
- **Level 2 Group that reports directly to the NAAG**

Task

Assure Interoperability of Future National Soldier Systems

- **Identify areas for standardization,**
- **Explore potential to adopt common subsystems/modules/components**
- **Identify implications for NATO doctrine and training**
- **Coordinate the work with appropriate Land Groups and other NATO Bodies**
- **Where appropriate develop Standardization Agreements**

The Soldier System Concept

A Soldier System is:
“ Integration of
***ev*erything the soldier**

- ***Wears***
- ***Carries***
- ***Consumes***

for enhanced individual and collective (small unit) capability within their national command control structure.”

Participating Nations

- Australia
- Belgium
- Canada
- Denmark
- France
- Greece
- Germany
- Italy
- The Netherlands
- Norway
- Portugal
- Spain
- Turkey
- United Kingdom
- United States
- Austria
- Azerbaijan
- Romania
- Slovakia
- Slovenia
- Sweden
- Switzerland
- Ireland

Overview of the Soldier System

The Complexity of Soldier System

Night Vision

Protective Eyewear

Radio

Computer

Ballistic Protection

Load Carrying

Weapon System

Gas Mask

Environmental Clothing

Integrate "each" into a Soldier System

Topical Group 1 on Soldier System Interoperability

Overview of the Soldier System

Integrated Fighting System

- Increased Lethality
- Soldier to Soldier Communications
- Digital reporting
- Enhanced Situational Awareness

Overview of the Soldier System

Integrated Fighting System

- Modular design
- Mission tailor-able
- Opportunity for Interoperability
- Links the individual soldier to the Digitized Battlefield
- Increased survivability

The Need

Different focus on different timelines

02	03	04	05	06	07	08

Australia

Canada

United Kingdom

France

Greece

Portugal

Netherlands

Italy

Spain

Denmark

Germany

Norway

United States

Belgium

NATO Soldier 2000 Demonstration

Bergen op Zoom The Netherlands June 2000

- For Senior NATO Officials and Military
- Presentations
- Static Displays
- Live Firing Exercises
- Tactical Demonstrations

Static Displays
11 Nations

Firing Demonstration

Tactical Demonstration

Critical Areas for Standardization

- C4I
- Combat Identification
- Power

C4I

Take C4I efforts to the individual level

- Data transmission protocols
- Agreed levels of voice, text, graphic, & video to effect C3
- Standard report format (small unit)
- Levels of filtering
- Common displays
- Common applications
- Common symbols

C4I

Status

- A procedure and methodology has been identified
- Several experiments have been conducted
- Draft STANAG by October 2002.

Issues

- TG/1 will establish capability to exchange information and communicate at the soldier level
- Current NATO and national policy is that this exchange is done at a higher level
- TG/1 feels this capability needs to be provided and leave it up to the military leadership to determine how to use it.

Combat Identification

Status

- Five Power Combat Identification Working Group (CIWG)
  - Has drafted a NATO Staff Requirement
  - Will draft a STANAG

- Draft NSR will be coordinated with TG/1, LG/6 and AC/322 SC7 this summer
- LG/6 will have the final action to approve and staff the STANAG

Issues

- None

Power

Status

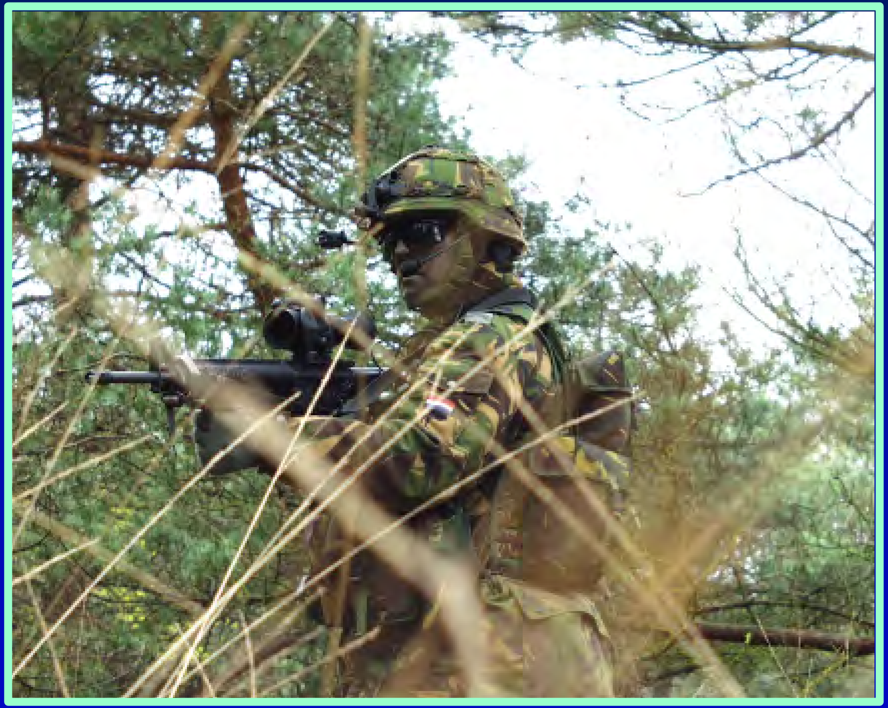
- ➢ TG/1 has drafted a STANAG to provide the ability to share power on the battlefield
- ➢ Draft is currently being circulated within the TG
- ➢ TG expects to approve it at the October 02 meeting for staffing

Issues

- None

Other efforts

- Vehicle Interface LGs 2 and 10
- Systems architecture
- Plugs and connectors
- Integrated helmets
- Protection levels



Summary

- Many nations are developing future Soldier Systems
- The opportunity exists for interoperability at levels not possible in the past
- NATO is committed to a coalition force with unequalled capability

Topical Group 1
has
the leadership
role
to assure
interoperability

Personalized Weapons Technology Project

NJIT

NJIT is a Public Research University

Biometrics

Presented by:

Mr. Lucian Sadowski
& Dr. Stephen Small

Briefing Outline

- Objective
- Background
- NJIT/ARDEC MOU
- Definition of a Personalized Weapon
- The Stakeholders
- NJIT Project Plan
- Initial Technologies Reviewed
- Project Survey and Assessment
- Dynamic Grip Recognition
- Approach
- Assessment of Risk
- Scientific Challenge
- Relevance to the Army
- Execution Plan
- Metrics of Success

Objectives

To investigate Biometrics for Small Arms Weapons
- Dynamic Grip Recognition
- Pressure Sensor Technology

Background

New Jersey Institute of Technology
- Personalized Weapon Technology Project
- Memorandum of Understanding

Background

- July 2000 – ARDEC Technical Director Signs Memorandum Of Understanding With The New Jersey Institute Of Technology (NJIT)

NJIT/ARDEC MOU Purpose:

- Collaboration in the research and development of smart gun technologies for military and civilian application
- Shared use of research and test facilities
- Joint pursuit of smart gun technology transfer between government, academic and private sector organizations

Working Definition of Personalized Weapon:

A A firearm whose capability to be fired is biometrically, mechanically, or otherwise safely rendered "authorized" user and/or users-only operational

The Stakeholders

- Law Enforcement
- Civil Community
- Military?

NJIT Project Plan

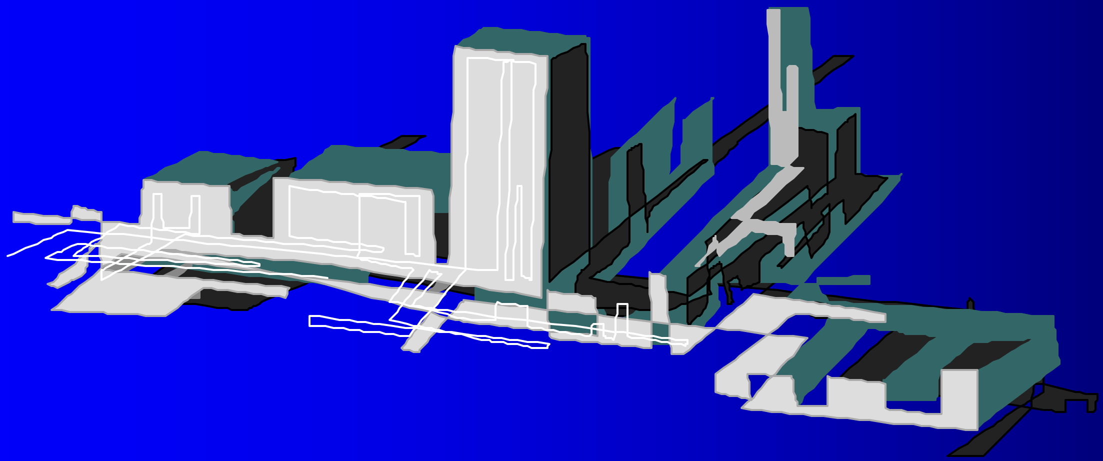
- Phase 1 - Literature Search
- Phase 2 - Tech Selection and Evaluation
- Phase 3 - Prototype Modeling/Fabrication
- Phase 4 - Prototype Simulation/Evaluation

Initial Technologies Reviewed

- Radio Frequency Tags
- Remote Control
- Touch Memory
- Lock Systems
- Biometrics I.D./Recognition

Initial Technologies Reviewed (continued)

- Voice
- Fingerprint
- Grip Pattern



Project Survey and Assessment

Personalized Weapons Technology Project															11/13/2000	
															a LMS Proc	
Evaluation of Items																
				Evaluation Factors												
Name	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**AVE**
Armadillo	5	2	5	3	3	4	4	0	5	1	5	1	1	9	0	**3.2**
MAGLOCK Push Button Trigger Lock	4	4	2	2	2	4	4	0	5	1	5	1	1	8	0	**2.9**
MAGLOCK Ring Activated Gun Lock	2	1	1	1	3	4	1	0	1	4	2	1	1	7	0	**1.9**
Master 90 Gun Lock	5	4	3	3	3	4	4	0	5	1	5	1	1	8	0	**3.1**
Mossberg Instant Access Gun Safe	5	4	5	5	4	5	3	4	5	3	5	1	1	9	1	**4.0**
Saf T Lok Magazine Combination Lock	2	2	5	5	2	3	3	0	5	3	3	1	1	7	0	**2.8**
Saf T Lok Revolver Kit Combination Lock	4	4	1	1	2	4	4	0	5	3	5	1	1	9	1	**3.0**
Securitylocks Pistol Box	4	4	5	5	4	4	4	0	5	3	5	1	1	9	0	**3.6**
Securitylocks Gun Safes	4	4	5	5	4	5	4	0	5	5	5	1	1	9	0	**3.8**
Securitylocks Master Cable Lock	5	4	1	1	2	5	4	0	5	1	4	1	1	9	0	**2.9**
Securitylocks CCL Cable Lock	5	4	1	1	2	5	4	0	5	1	5	1	1	9	0	**2.9**
FIREARMOR Lockable Clam Shell	4	4	1	1	4	4	3	0	5	3	5	1	1	9	1	**3.1**
PHALANXLASH	5	4	1	1	3	4	4	0	5	3	3	4	3	9	1	**3.3**
Saf T Blok External Trigger Lock	5	4	1	1	3	3	5	0	5	1	3	3	1	9	0	**2.9**
Speed Release Electronic Trigger Lock	4	4	3	3	3	4	3	4	5	2	2	1	1	9	0	**3.2**
iGun	5	4	3	3	3	3	1	3	5	4	3	1	1	6	1	**3.1**
EtronX	5	4	1	1	4	4	4	3	5	5	4	3	3	9	1	**3.7**
TAURUS	4	4	1	1	3	4	4	0	5	1	4	3	1	9	1	**3.0**
	4.3	**3.6**	**2.5**	**2.4**	**3.0**	**4.1**	**3.5**	**0.8**	**4.8**	**2.5**	**4.1**	**1.5**	**1.2**	**8.5**	**0.4**	

(a)

(b)

Approach

Collaboration in Research between NJIT and CCAC

- NJIT - Dynamic Grip Recognition
  - Pressure Sensor Technology
- CCAC - Weaponization Expertise
  - Recognition on a Weapon
  - Test Vehicle
    - Compact, 9mm, Pistol
  - Effects of Benign and Stressful Environments
    - Include Live Fire Testing
  - Approaches for Impairment of the Weapon Function

Assessment of Risk

- Repeatability of Recognition
  - Benign and Stressful Environment
- Reliability of the Recognition Grip Pattern Sensors
  - Benign and Stressful Environment

Scientific Challenge

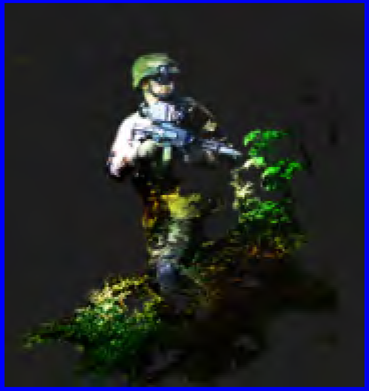
Using Biometrics as I.D. Recognition - User Only Operational

- Reliability of Recognition
  - Benign and Stressful Environment

- How can the firearm architecture be best impaired

- Transparency to the operator

- Affordable



Relevance to the Army

Firearm capability is biometrically rendered "Authorized" user(s) only operational

This technology can be applied to other items where a "lock and key" system is currently being used.

No longer will a military item not function because a password is forgotten or a key is lost in the heat of battle.

Execution Plan

- Identify Interfaces - Start with Design of Interface - Initiated
- Pressure Sensor Technology - Complete Design of Interface
- Incorporate “Dynamic Grip Recognition” into Weapon
- Demonstration of Technology -
    - Benign Environment - July 2002
    - Stressed Environment - September 2002

Metrics of Success

Quantitatively
- What is the recognition rate in both environments ?
- How reliable is it ?

Qualitatively
- Transparency to the operator
- Impairment to weapon function

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Rapidity With Accuracy:

Modernizing the U.S. Army Service Rifle in the Gilded Age 1880-1903

Presented by
Stephen C. Small, Ph.D.
Of the Joint Service Small Arms Program (JSSAP)

Briefing Outline

- Introduction
- U.S. Army Service Rifles (1776-2002)
- The genesis of the military “repeating” rifle
-- The Post-Civil War U.S. Army (1880-1889)
- Legacy Weapon: The “Trapdoor” Rifle
- The “Krag” Rifle
- Catalysis for change: The Spanish-American War
- San Juan Hill: A Watershed Event
- The Spanish Mauser
- The American Mauser: The M1900 “Experimental” Rifle

Briefing Outline (Cont.)

- The Refined Prototype: M1901
- The Success Validated: The M1903
- Catastrophic failure
- The Enabling Spitzer Bullet and The .30-06 Springfield
-World War I: The M 1903 in Action
- The Impact of “Rapidity with Accuracy”
- Summary

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Lethality, Survivability, Mobility and
Sustainment for America's Army

U.S. Army Service Rifles (1776-2002)

1880-1903

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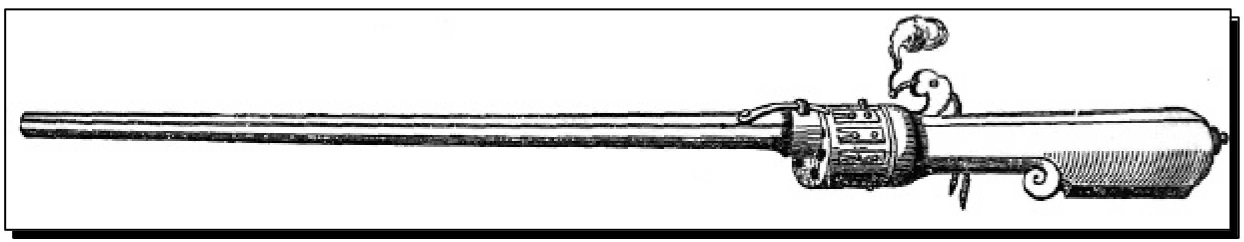
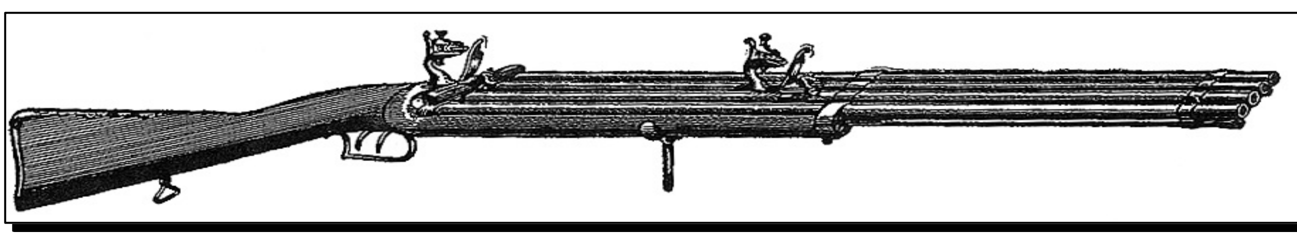
Introduction:

•During the late 19th century technological advances made reliable repeating rifles a practical reality for military usage.



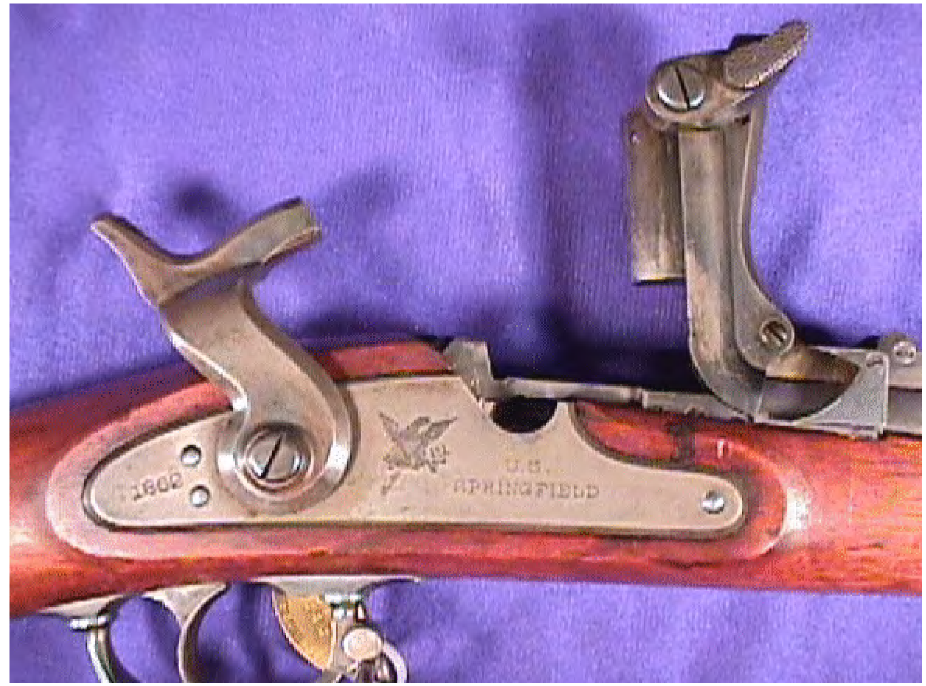
17th Century Self-Loading Gun



18th Century "Repeating" Rifle

The U.S. Army Circa 1880-1889

The "Trapdoor" Rifle 1868-1892



The “Trapdoor” Rifle

Action:	**Single-shot breech-loader**
Total length:	**52 inches**
Length of barrel:	**36 inches**
Rifling:	**3 grooves, making one turn in 22 inches.**
Stock length:	**48-3/4 inches**
Weight:	**8.25 pounds**
Ammunition:	**.45-70**
Charge:	**70 grains**
Weight of projectile:	**405 grains**
Muzzle Velocity:	**1,360 f.s.**

The "Krag" Rifle: M1892 (Above) and M1898 (Below)

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"Krag" Bolt-Action and Magazine (viewed from above)

The "Krag" Rifle

Action:	**Bolt action**
Total length:	**48 7/8 inches, two bands**
Length of barrel:	**30 inches**
Rifling:	**4 grooves, one turn in 10 inches.**
Stock length:	**46.05 inches**
Weight:	**8.97 pounds**
Ammunition:	**.30-40 flanged cartridge**
Magazine capacity:	**Vertical, under-feed, 5 rounds, but also capable of functioning as a single shot weapon.**
Charge:	**40 grains of smokeless powder**
Weight of projectile:	**220 grains**
Muzzle Velocity:	**1,960 feet per second**

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The War With Spain 1898

Lethality, Survivability, Mobility and Sustainment for America's Army

Teddy Roosevelt's "Rough Riders" in The Spanish-America War

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Close Combat Armaments Center

J.S.S.A.P. JOINT SERVICE SMALL ARMS PROGRAM

The “Krag” Carbine

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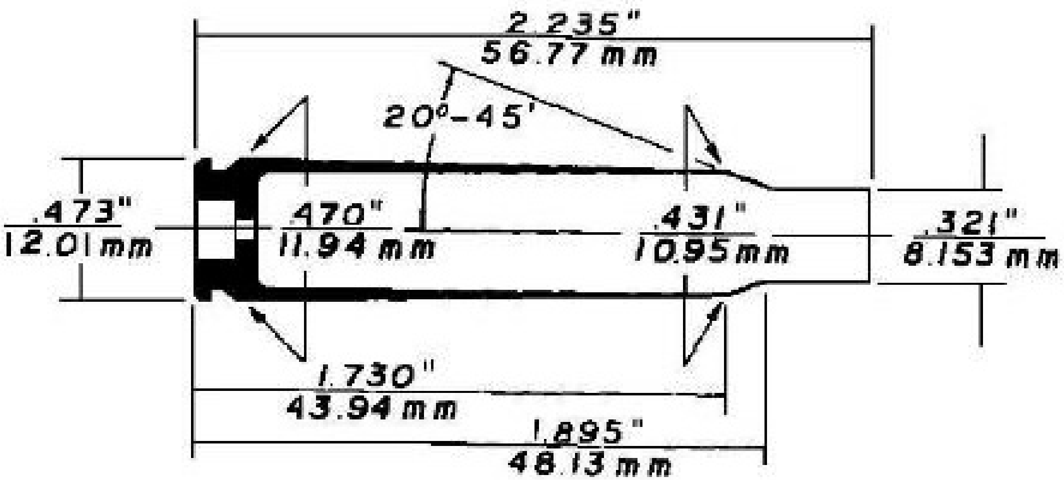
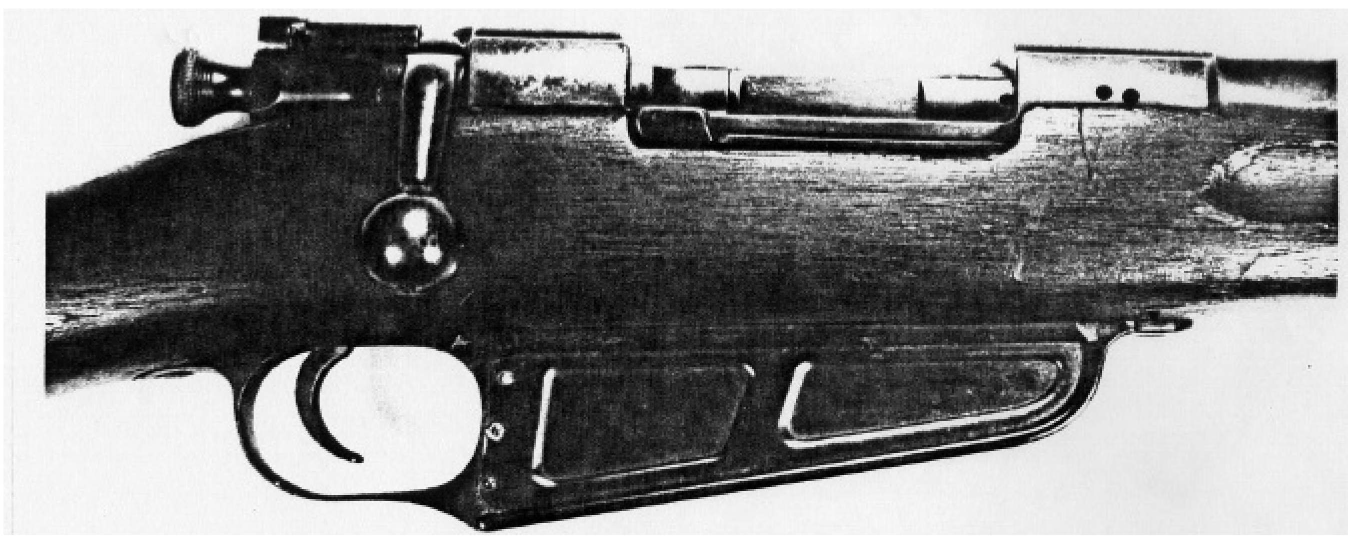
San Juan Hill, Cuba
July 1, 1898



The Spanish Mauser (7x57 mm)

The M 1900 Experimental Rifle



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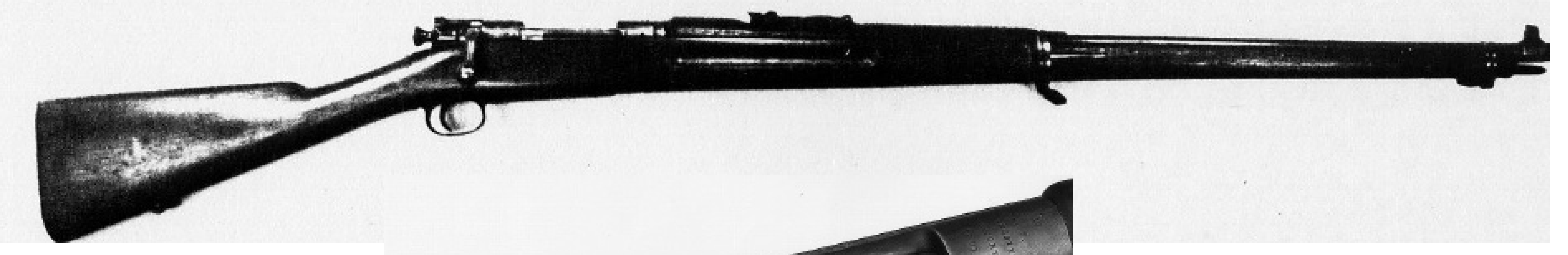
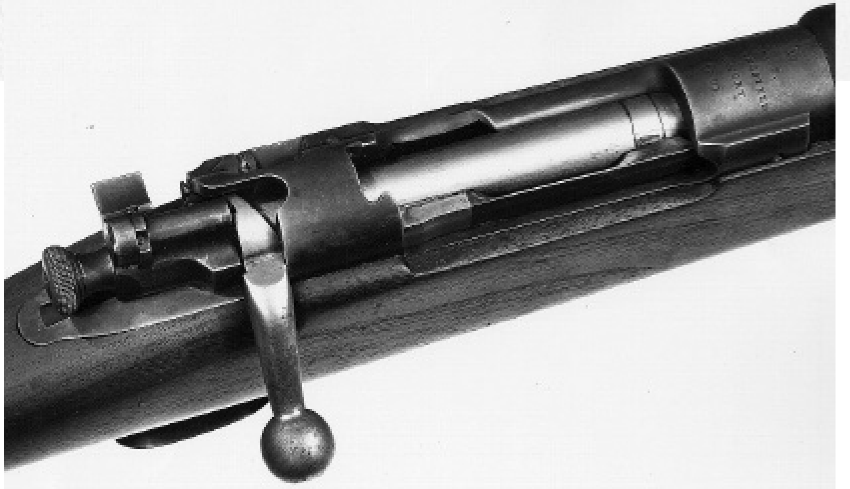
The M 1901 Springfield Rifle

Rimless .30 Caliber M1901





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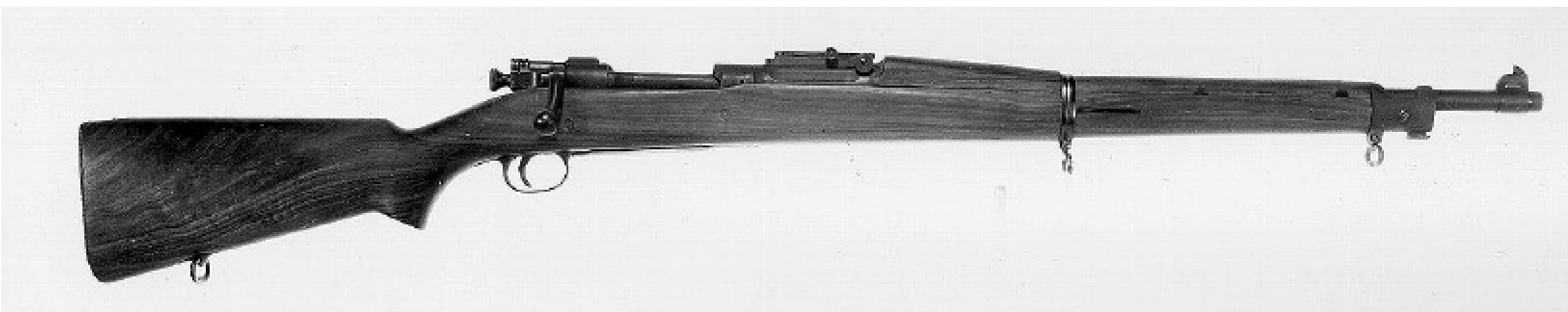
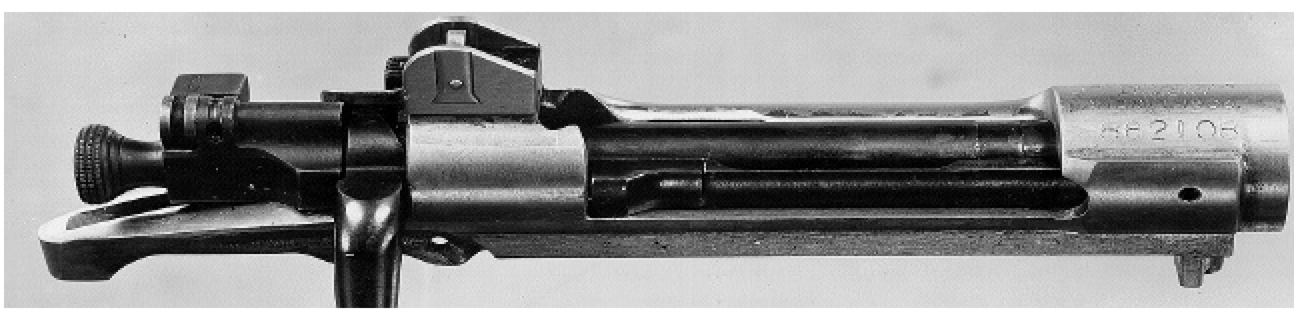
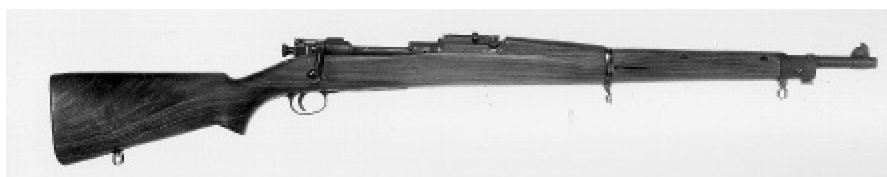
The M 1903 Springfield Rifle .30-06



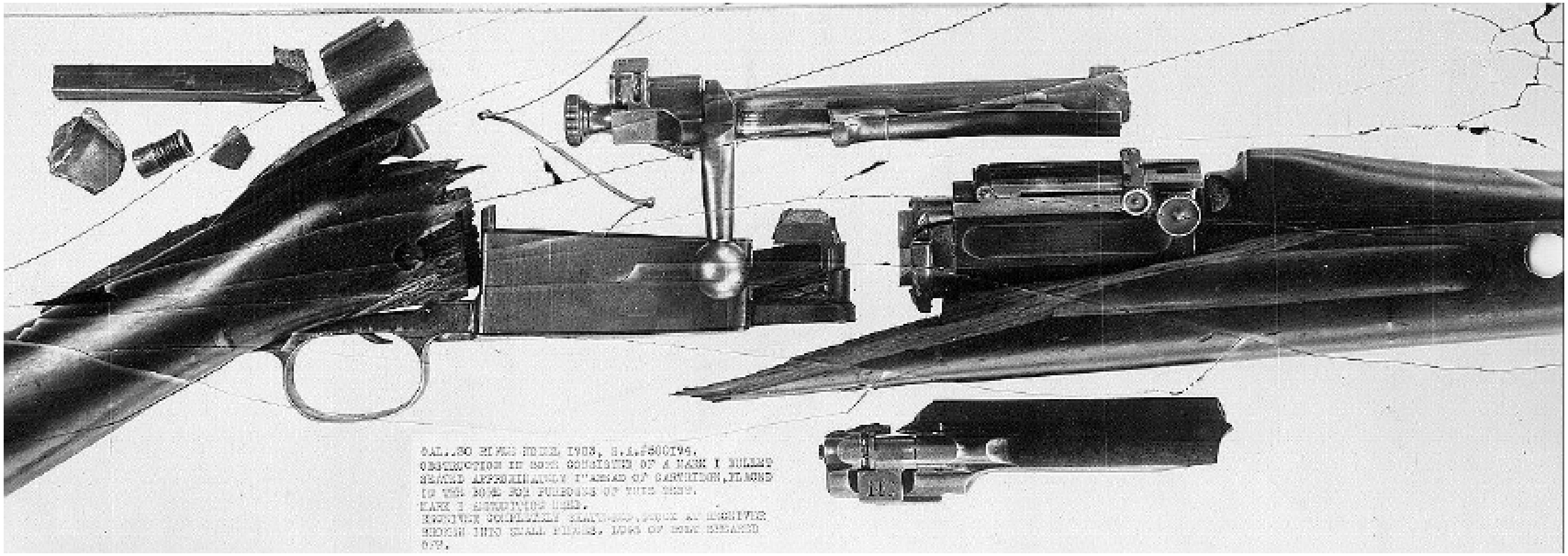


The "M 1903" Rifle:

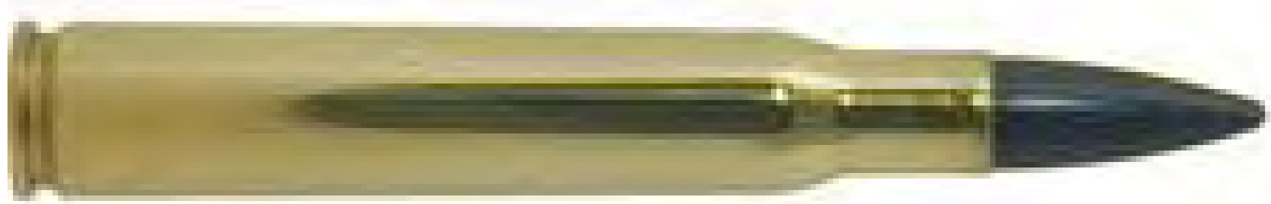
Action:	**Bolt action**
Total length:	**43.2 inches**
Length of barrel:	**24 inches**
Weight:	**8.68 pounds**
Ammunition:	**.30-06 cartridge**
Magazine capacity:	**5-rounds, internal**
Charge:	**48 grains of smokeless powder**
Weight of projectile:	**150 grains**
Muzzle Velocity:	**2,800 feet per second**



Accidents will happen…



The Enabling Spitzer Bullet and The .30-06 Springfield



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WORLD WAR I
U.S. Soldiers In 1917

Lethality, Survivability, Mobility and Sustainment for America's Army

"They did have machine guns, and they did have **modern bolt action rifles.**..I think, it's the intensity..the degree of destruction; the effects they had on men's ability to remain above ground in the battlefield without suffering horrendous casualties."

The Great War: Interviews
Simkins: Modern Warfare

Summary

- Economic
  - The presence of large numbers of legacy systems tend to slow technological change in small arms systems
- Cultural
  - Developers and Users sometimes favor special purpose weapons (carbines) and during other periods attempt to unify all long-arms into one universal service weapon

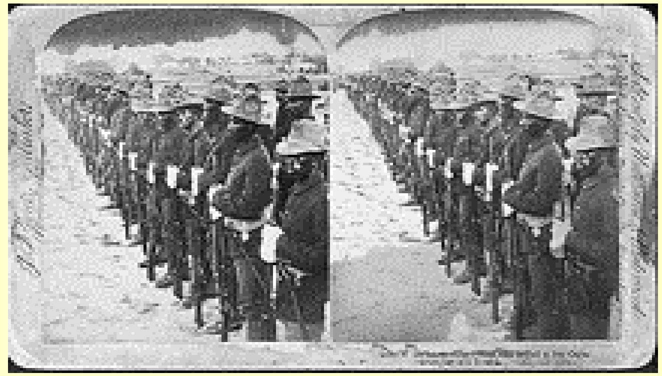
Summary

3. <u>Technological</u>

- Absolute originality is rare, developers tend to be eclectic, e.g. they adopt and adapt the useful
- Emerging technologies tend to add complexity to small arms
- Ease of operation, ruggedness and durability are dissatisfiers

TACOM

Lethality, Survivability, Mobility and Sustainment for America's Army



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